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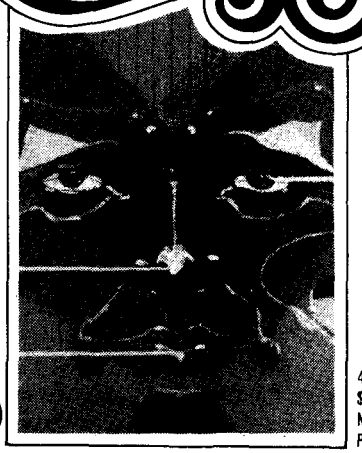

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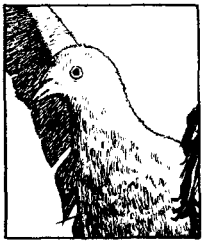

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Editorial by Stanley Schmidt

INVENTIONS WANTED

Within the last couple of weeks (before this writing), two noteworthy events occurred. One of them received a great deal of publicity; the other did not. History may well show both to be more important than many onlookers believed at the time.

One was the fiftieth international meeting, in Baltimore, of the American Institute of Aeronautics and Astronautics—the first scientific meeting I have attended which included science fiction writers as invited speakers on its regular program. Most of the speakers were scientists, engineers, industrialists, politicians, and military men who are shaping into reality many of the dreams of science fiction. The inclusion of science fiction writers seemed to me an unprecedentedly open acknowledgment of the way science and fiction have goaded each other on in the past, and may encourage an even more fruitful interaction in the future. One special session, open to the public, was a panel of science fiction writers, during which Frederik Pohl talked about "social inventions," such as new political and economic systems, and the way they are often both products and producers of "hardware" inventions. (Consider the automobile, for instance, and the ways our society has changed since before its advent.) The Baltimore meeting also included a showing of a film about "High Frontier," a novel, space-based system of national defense—nonnuclear, aimed at survival rather than "Mutual Assured Destruction," and *purely defensive*—proposed by a team of scientists, engineers, strategists, and economists led by Lt. Gen. Daniel O. Graham (U.S. Army, Ret.).

My other noteworthy event—the one with lots of publicity—was the huge disarmament rally in New York City on June 12, held in conjunction with a special United Nations session on disarmament. I wasn't there, but I had highly regarded house guests who were, so I have some knowledge of it from a perspective other than that of the news media. (Coincidentally, I simultane-

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ously had another highly regarded house guest who is professionally involved in the development and evaluation of nuclear weapons systems. See? Peaceful coexistence *is* possible!) Nobody knows how many people were at the "anti-nuke" rally (people who have made their own counts of crowds have developed a healthy distrust of news reports), but I have heard no estimates lower than half a million, and some well over a million. It was the largest political demonstration in U.S. history, and while it was the first of its kind here, there have been many in other countries recently, seeking at least a reduction in nuclear arms by major powers, and in some cases considerably more.

Needless to say, efforts at disarmament are controversial—to put it mildly. People who have aligned themselves with one side or another (there are, of course, many more than two) often take heated shots at those on "the other." Some who believe a continued buildup of nuclear arms is essential to our survival dismiss proponents of disarmament as "naive, unrealistic, and unpatriotic," assuming that they are ignorant of the dangers of external invasion or even conspiring to facilitate it. Some advocates of disarmament paint a pretty black picture of everything and everybody military, hinting that they can have no motives more admirable than those of the greediest conqueror in history or comic book.

I happen to know, from personal contacts, that there are individuals in the "military-industrial complex" whose motives are a good deal subtler than that—who sincerely believe, on the ba-

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sis of all information at their disposal (which may include some not available to the general public), that what they are doing *must* be done to ensure their country's survival. I also know that there are "anti-nuke" protesters who have done a great deal of research, are acutely aware of the dangers, and have been thinking very hard about better ways to cope with them.

Certainly there are extremists and naive or simplistic individuals—on *both* broad sides of the controversy. I would personally tend to class as extremists those people who really believe that MAD (Mutual Assured Destruction) is a sensible basis for a defense program. I would also class as extremists those few disarmament advocates who want immediate, total, unilateral disarmament, without considering the fact that there *are* external threats and suggesting an alternate form of defense against them. I would call simplistic those participants on either side of the fence who totally dismiss everybody on the other without listening to what they have to say.

From my admittedly limited point of view, two propositions seem fairly clear and central to the whole debate:

1. There *are* external threats to the security of this or any other country, and there will be others in the future. Pure, total, unilateral disarmament, without the adoption of a well-thought-out alternative method of defense against those threats, could well be suicidal —maybe not immediately, but eventually.

2. MAD is *mad*. Continued escalation of a nuclear arms race seems most unlikely to benefit anybody in the long run, and a balance of terror is hardly a worthy way for a "civilized" species to keep itself alive. If anybody actually *uses* the nuclear arsenals already available, nobody wins (except perhaps in the most grimly ironic sense)—and everybody loses. Each major faction already has more than enough capability to destroy the other in an unblocked first strike, and there is no state deader than dead. As mountain climbers say in regard to falling, "After fifty feet, it's all academic." The sole justification offered for continued increases is to give each side enough ability to block and retaliate to insure that if A destroys B, B can take A with it. Some solution, huh? The theory, such as it is, is that neither side will dare *use* its weapons because doing so would destroy attacker as well as attackee. Personally, I've never found it very convincing. History suggests that if a capability exists, sooner or later somebody will use it—no matter how crazy it is. There is also the possibility of *accidental* discharge of weapons. Most people would agree that loaded firearms should not be kept in the house, but our governments are keeping gadgets which can do *vastly* more damage as a result of a negligibly larger slip.

The only positive protection against nuts and klutzes, it seems, is to see to it that *nobody has* that kind of weaponry. If it's true that any capability we have will eventually be used, the only way to positively prevent that use is to remove the capability.

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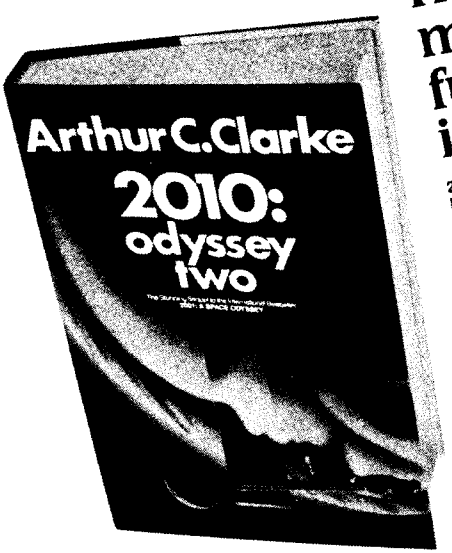

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"But," people often protest at this point, "the cat is out of the bag. There's no way to get it back in, ever again."

True enough, if the cat in question is knowledge of nuclear processes. As John Campbell liked to say, "Mother Nature is a blabbermouth." Burn the books on nuclear physics this year, and you just make your children vulnerable to whoever rediscovers the contents next. Nor, quite emphatically, would I *want* to see them burned. Allow me to point out a fine but exceedingly important distinction: nuclear *theory* never killed anybody; only *specific applications* can do that. You not only can't, but shouldn't, destroy the knowledge. Knowledge is always at least potentially useful, and never more than potentially dangerous. Nobody who lacks the *hardware* has the *actual* capability of wreaking havoc. If *everyone* is prevented from building or owning nuclear bombs, the danger goes away—no matter how knowledgeable everybody is about the nucleus. (I, for one, would like to see most people a lot more so—but that's another story. It's called "Evil Spirits.")

How, in practice, can you make sure that everyone, worldwide, disarms? I don't know. Compared to what it's probably going to take, I've barely begun to think about it, and I haven't met many people who have a really impressive head start on me. I suspect it's a formidable job—but *impossible?* I'm no more prepared to assume that than I am to assume that interstellar flight is impossible—or than I was to assume that *lunar* flight was impossible thirty years ago. A big job, yes, probably requiring fundamentally new ways of looking at things. But if lots of the brightest, most imaginative people in the world begin working on it *now*, thinking not in terms of why it can't be done, but in terms of *how* it *can* . . .

I expect answers.

Meanwhile, what's to be done about the danger of external attack while everybody is still armed to the national teeth? MAD is a dead end. How about

(Continued on page 148)

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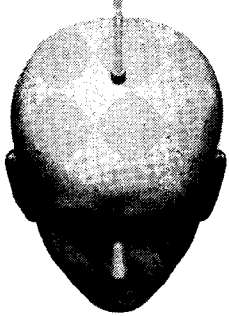

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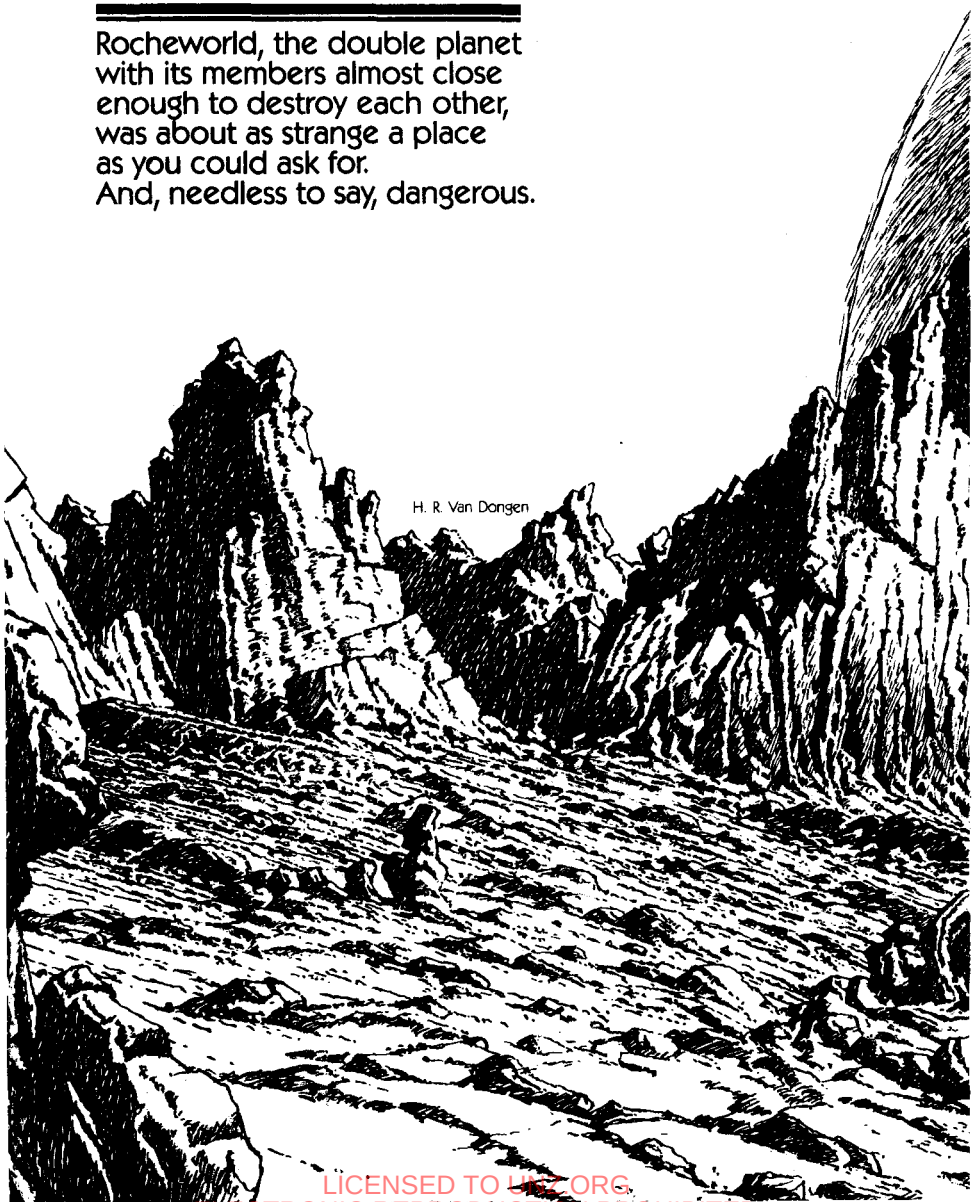
Dr. Robert L. Forward

Part One of Three

ROCHEWORLD

Rocheworld, the double planet with its members almost close enough to destroy each other, was about as strange a place as you could ask for. And, needless to say, dangerous.



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BEGINNING

The torn shred of aluminum light-sail rippled lightly down through the thin atmosphere to settle on the calm ocean. The unmanned interstellar probe the sail once had carried was heading back out into the blackness of space, its flyby study of the Barnard Star planetary system completed. The messages from the probe would reach Earth six years later. The micro-thin film of aluminum was no match for the ammonia-water ocean covering this egg of a planet, and the sail dissolved into a bitter taste of aluminum hydroxide.

Clear `White `Whistle was warming on the ocean surface in the red glare from Hot. Hot suddenly became less. The lessness was not like the darkness that came from a storm shadow, but much sharper. It was almost as if Sky:Rock had suddenly moved in front of Hot. Suddenly there was a thin sharp taste of bitterness in the ocean.

Clear `White `Whistle dove under the ocean to escape the bitterness, then came to the surface. The taste was still there—another dive—it was there too. A deep, sounding dive a long distance away . . . it was still there, but the sheet of darkness was being eaten by the ocean and Hot peered through the holes.

For a long time Clear `White `Whistle tasted the bitterness and thought about the strange thing that had come from nothing but was something. Thoughts came to it about exploring the nothing above, but that was impossible. . . .

`But only carefully contrived mathematical propositions are truly impossible, ` mused Clear `White `Whistle. `I can look into nothing, although poorly. I know Hot and Warm are sources of light and heat, but though I have tried hard, I cannot see them. If only my looking portions could be focused like my seeing portions . . . `

A thought came and the large amorphous white blob of jelly condensed. Clear `White `Whistle turned into a dense white rock and sank to the bottom of the ocean. The concentrated whiteness of its brain now thought at a higher rate. Equations for a focusing detector based on time differences went through a sophisticated mathematical transformation to become the equations for a focusing detector using distance differences—a detector that would "look" using light instead of "seeing" using sound. The mathematical solution now obvious, Clear `White `Whistle, the toolless engineer, dissolved and swam again to the surface as a long undulating white cloud. The thinking had taken a long time. Hot was gone. It had moved behind Sky:Rock, a large object that hovered motionless in the sky above this region of the ocean. The shadow line on Sky:Rock had moved around to the other side and Sky:Rock no longer gave off its rocklike reddish-grey light. The sky was not completely dark, however, for Warm had risen and was now a weak flare overhead.

Using the mathematical equations as a guide, Clear `White `Whistle formed a portion of its body into a sphere and removed the white thought to leave a clear gel. Through the crystalline sphere streamed the rays of light from the heavens, to come to a crude focus in the opposite hemisphere. The white flesh

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next to the clear sphere looked at the tiny pattern of light impressed on its surface. The light patterns showed Warm as a tiny disk of mottled red. Around Warm were smaller bright lights with sharp cusps and fuzzy edges.

A further adjustment of the sphere into a crude lens, and the distorted spots turned into smaller disks. As the lens focused on the moons of the giant red planet, Gargantua, the blackness of the night sky blossomed with thousands of tiny pinpoints of light. Clear `White` Whistle stared with its newly invented "eye" at the multicolored stars in the sky and wondered.

STOPPING

"Laser beam contact!" the computer announced to General Virginia Jones, its normally soothing baritone taking an imperative edge.

"Wha?" murmured General Jinjur, rousing from her stupor in front of a television screen displaying an old John Wayne battle movie. Deep within her mind she sensed a martinet screaming at her, "Wake up, you dummy! You're in charge!" She shook her head. This was no way for a mission commander to act. She floated clumsily across the control deck to pull herself into the central command seat.

"Report ship status, James!" she rasped in a weak imitation of her parade voice.

James spoke through its imp, which was nestled in her hair. "I detect low-energy laser beams from Earth. It is time to bring *Prometheus* to a stop at Barnard. I quit putting the No-Die drug in your water a month ago. It is now time for the rest of the crew to be taken off of it." There was a slight pause and the friendly voice of the computer took on a formal note. "As Commander, you have the authority to countermand this prearranged plan, but you will have to elucidate your objections in detail."

Jinjur blinked at the last few confusing words as James dropped back into its normal voice: "But you *do* want me to stop the drug, don't you, Jinjur?"

Appalled by her mental weakness at this critical juncture, Jinjur grabbed her thick cap of fuzzy hair and shook her head with her muscular black arms, trying to wake the numbed brain inside. "Yes! Yes! Do it! Flush out the tanks, get rid of that stuff! I want to be *me* again!"

"Take it easy, Jinjur," said James. "I will do it right away. It will take a few months, however, before everyone recovers completely. I will be looking forward to it. It has been dull playing nursemaid to a bunch of ageless imbeciles these past four decades."

Jinjur, knowing that the computer had everything under control, let her stupefied brain relax and floated slowly back to the TV to watch the Marines on the screen storm up the beach for the thousandth time.

Three months later the members of the crew were back to their normal aging rates and IQ levels. The precursor laser beam from the solar system had been getting stronger as Mercury Center tuned up the laser transmitter system. Full power would come in about ten days, and they needed to get ready. A few had strayed from their work stations to peer

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in fascination down the Earthside science dome at the orange speck of light glowing like a bright jewel in the belt of Orion.

"I'm almost glad they had trouble building the transmitter lens, so they had to triple the laser frequency into the visible to compensate," said David Greystoke, trying to absorb every nuance of the scene with his artist's eye. "It always bothered me that we could never see the laser beam that was pushing us because it was in the infrared."

"Don't you wish we weren't moving so fast, so Orion's jewel would look like an emerald instead of a topaz?" said Gretchen Krupp. The tall Chief Engineer flipped her single long yellow braid back over her shoulder to keep it out of David's eyes as they both looked down through the dome. The precursor beam was not very strong, but it did give a perceptible acceleration to the sail, and the crew had to readjust from decades of living in free-fall.

"It'll change," said David. "We're moving at 20% of light now, so the blue-green laser frequency is red-shifted by 18% to orange. But as we come to a stop at Barnard, it'll move back to green."

"Like modern alchemists," mused Gretchen. "Transmuting topazes to emeralds."

"Just a wave of the magic relativity wand."

They heard noises at the airlock and turned to see the Christmas Bush operating the airlock controls. The large bush-like motile that the computer used as its "hands" was getting ready to go out. The inner airlock door opened and the Christmas Bush seemed to drop all its needles as it came apart. The major trunk and limbs stayed in one piece, but 1,080 of the 1,296 twig-sized clusters on the bush detached themselves and swarmed into the lock, each one about two centimeters across. Like the main Christmas Bush, each glittered with tiny colored lights that came from laser diodes that the motiles used for sensing, communication, and power transmission. James pumped the lock down, then opened the outer door. The twigs swarmed out across the hull to the shrouds that stretched out to connect the central payload with the sail, whose silvery sheen stretched past any horizon the human eye could see. Like mice climbing a ship's hawser, the twigs marched in single file, splitting their forces each time they came to a branching in the shroud pattern. The crew watched the progression of the mites for a while over the monitors, but soon lost sight of them in the orange glare. The twigs moved rapidly, but they had 300 kilometers to go and would not reach their posts for nearly a day.

Jinjur was at her console on the command deck, monitoring the loading of a copy of James's memory into a computer stationed on the outer rim of the sail. It was one of three redundant units spaced around the rim of the sail. The computers had stayed dormant during the trip out. They were not as powerful as James, but were complex enough to be semi-intelligent and had been given names.

It was the job of Snip, Snap, and Snurr to run the deceleration stage of the interstellar sailship. *Prometheus* was now only a quarter of a light-year from

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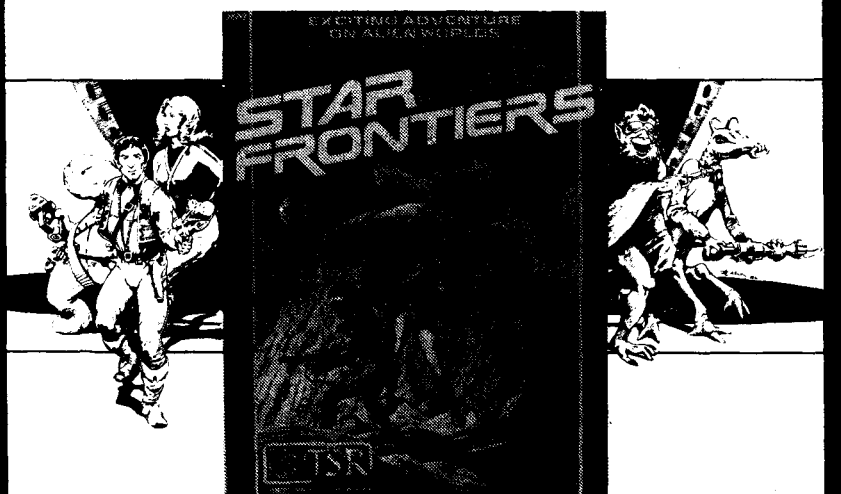

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Barnard, and it was time to stop. To do that, the sail would be divided into two pieces: a circular inner portion 300 kilometers in diameter that supported the main spacecraft with the crew, and an outer ring-shaped portion, a silvery doughnut 1000 kilometers in diameter with a 300-kilometer hole.

On the way out, the complete 1000-kilometer sail had worked as a single unit, driven by the infrared light pressure from the launching lasers in orbit around Mercury. The deceleration phase was trickier, however, and would require all the brainpower of Snip, Snap, and Snurr if the humans were to be brought safely to a stop at Barnard. The outer ring sail had to be reconfigured into a concave mirror. Its purpose: to reflect and focus the beam of laser light coming from Mercury Center onto the the payload sail to slow it down.

"David," said Jinjur. "Stop admiring the pretty lights and go back to your computer console. The computer dump into the triplets is about done. I want you to check and make sure everything's okay."

David looked up at Gretchen and raised his eyebrow, the fine orange-red hairs almost invisible in the orange glare. Having worked with computers all their lives, both knew that if any problem had eluded the checks built into the transfer program, there was little chance a mere human could find it. Nevertheless, David tore himself away from the view and padded over to take his seat at a computer console. He took James and the triplets through their verification routines and nodded to Jinjur.

"Ringsail computers operational, General Jones," he said.

Hearing the use of her military title made Jinjur wince a little. David was right. She had been overbearing, but this mission had had its share of bad luck already. She gave David a weak grin. Still unrepentant, however, she roared in a voice that those on starside swore they could hear through the lift-shaft.

"Stand by for breakaway! 10-9-8 . . ."

One-third the way out on the sail, 1,080 mechanical tarantulas waited for their light-beam orders. A pulse of laser light from the remains of the Christmas Bush standing up in the starside science dome carried a coded signal out to each of them, and the tarantulas started walking, snipping the weak links between the inner and outer sail. The spiders had to travel almost two kilometers, snipping as they went. It was about an hour before they finished. The spider-imps then started their day-long journey back across the 300-kilometer sail and down the shrouds to reattach themselves to the Christmas Bush.

The orange laser beam became stronger. The outer ringsail accelerated under the light pressure, while the inner sail, with its heavy payload section, accelerated more slowly. As soon as the two portions had drifted a few thousand kilometers apart, Jinjur took command and turned the central sail around to face the focused energy coming from the ringsail. Since the ringsail had ten times the surface area of the central sail, the latter now received ten times as much pressure from the ringsail as from the solar system. The acceleration on the humans built up again, stronger than before, but now it was a deceleration

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that would bring them to a stop at Barnard.

"This is terrible," said Richard Redwing as he stomped heavily about the lounge. He almost dropped his squeezer as he collapsed into a chair and stuck there. He looked with annoyance at Sam Houston, who had found some old Scotch bottles in his room and was now practicing pouring water from one to the other.

"It's only 1/10 gee, Richard," said Sam. "It's about what we expect on the moons about Gargantua, so it should be good practice for you."

"You can have it," said Richard. "I'll stay here on *Prometheus* and let you go down."

As the days passed, the tenth-gee acceleration built up an appreciable velocity difference between the slowly decelerating central sail with its heavy payload and the ringsail, shrinking in the distance. After a few months even the human eye began to notice the difference in colors impinging on the lightship. Toward Barnard, the brilliant beam from the tiny doughnut of the ringsail slowly changed from orange to red, while from the other side, the direct beam from the Earth began to take on a definite yellow tinge. After a year the beam from Earth had shifted color from topaz through amber to emerald, while the ringsail beam had darkened to a red so deep that only some of the crew could see it. They were now within light-months of Barnard and the crew took out telescopes, particle counters, and other sensors and began collecting the scientific data that was the primary reason they had been sent on the long journey. They soon were all busy looking out the rechristened "Barnardside" science dome, studying the deep red sun, the supergiant planet Gargantua with its retinue of moons, and the double-planet, Rocheworld, with its strange figure-eight shape. As they were passing through the outer asteroid belt beyond Gargantua, the science activities took more and more of their time. Only David occasionally made himself travel to the starside science dome to look in awe at the brilliant aquamarine jewel studding Orion's belt.

A few months later the time came to turn off the laser beam. The central sail had been slowed until it was firmly in the gravitational grasp of the dull red star, while the ringsail carrying the abandoned semi-intelligent orphans, Snip, Snap, and Snurr, faded into invisibility among the sprinkle of stars in the heavens. The whole crew was watching out the starside science dome as the time came. The blue-green aquamarine flickered, then guttered slowly into oblivion, leaving a faint yellow-white star in its place. They had arrived at Barnard's Star, their home for the rest of their lives.

With the laser power off, *Prometheus* had to make do with the weak red photons from Barnard. Although not powerful enough to have slowed the lightsail in its headlong relativistic flight, the light pressure was enough to swing the sail into a looping orbit that took *Prometheus* on a journey past the major planets in the system. By using the light from Barnard to add to their orbital speed, Jinjur and James could travel away from the star to the outer portions

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of the system. Tilting the sail the other way would slow their speed in orbit and allow *Prometheus* to drop in closer to the sun.

Sailing carefully, *Prometheus* rendezvoused with Gargantua and allowed itself to be captured in a trajectory that would take them past all of the moons in this miniature solar system.

After a preliminary survey of the Gargantuan moons, Jinjur started the long trip back into the inner Barnard system to map Rocheworld, the most interesting feature of this strange stellar system.

"How does it look, Thomas?" she asked, looking off to her right at the handsome black astrodynamicist.

"James and I have the trajectory of Rocheworld pretty solid, but we found something that raises some questions," said Thomas St. Thomas. "We have old data from the flyby probe that we're still arguing about. James thinks it's too perfect. Either there's been absolutely no change in Rocheworld's orbit in fifty-plus years, or else there's been a significant shift and things just happened to match up when we got here. I'm arguing that the second is implausible, but James seems to want to believe in the laws of entropy, that things must run down, and it is impossible for Rocheworld's dynamics not to have changed in fifty years."

"What's the problem?" asked Jinjur.

"James and I have tracked Rocheworld's two planetoids very carefully with radar. Rocheworld is in a highly elliptical orbit with a period that James is sure is *exactly* one-third that of the orbital period of Gargantua. The elliptical orbit brings it within 4,600 megameters of Barnard at periapsis, then it swings out to 32,000 megameters at apoapsis. Once every three orbits, Rocheworld passes within 6,000 megameters of Gargantua."

"That's just outside Gargantua's moon system! That sounds significant," said Jinjur.

"James and I think that one of the two parts of Rocheworld must have once been a moon of Gargantua, with the other one being another moon in an elliptical orbit or an interloper from outer space. The only way we'll find out is to visit there."

"Okay," said Jinjur. She looked across the control deck at the two aerodynamicists and pilots, Col. George Gudunov and Arielle Trudeau. "Had enough sightseeing, you two?" she asked. "Don't forget, we'll be back to study Gargantua's atmosphere in more detail after we've completed the survey of Rocheworld. At least on Rocheworld you'll be able to get in some flying time."

George punched a few more keys on his console, pointed to a few features on the screen, and watched as the computer extracted a few more bits of information out of the closeup picture of a giant hurricane on the slowly rotating super-massive planet. He turned and looked at Arielle, working at the next console. The young Quebec beauty queen looked back at the old Air Force flight instructor and shrugged.

"We have so many picture of Gargantua we know him outside in," she said.

"All yours, Jinjur," George said. He wearily got up from the science console chair, and stumbling a bit on unused

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legs made his way to the lift-shaft and his bed. Arielle went to bed too, but first she stopped off at the sick bay to get patches for her cracked fingernails, then the galley to get a bite to eat. She had a double helping of proto-cheese with real garlic from the hydroponic gardens, two algae-shakes with energy sticks mixed in for crunch, then, still hungry, finished with a dessert consisting of a half-pound of white-meat sticks from Chicken Little—her real-meat ration for a week—sliced into thin strips and hot-cooked with James's secret recipe of herbs and spices.

When *Prometheus* had first arrived at Gargantua, Rocheworld was on the inbound leg of its highly elliptical trajectory. While they were taking pictures of the giant planet and its moons, the tiny double-planet went through its close periapsis passage about Barnard. The point of closest approach was on the side of the sun where they were. They tried to follow it across the distant red disk with telescopes, but most of the detail was hidden by the deep red glare of the fuzzy globe of light. Rocheworld was now coming out again to meet them, slowing rapidly as it climbed up out of the deep gravity well. They dropped inward, then applied full light-braking to match orbits with the twin planets.

Like a pirouetting pair of gumdrops, the two planetoids that made up Rocheworld whirled along their orbit. The two lobes were gravitationally distorted into egg shapes that looked like an infinity symbol when seen through one of Thomas's low-power camera lenses. Six years later on Earth, the scientifically blurred but artistically fascinating image would be "the" Christmas card of 2076.

Jinjur approached the double planet with caution. "Don't get too close, James," she said. "I want you to spiral in slowly and monitor the shape of the sail as you do. The rotating double-lobed gravity pattern of that eggbeater is something that neither you, nor I, nor the designers of the sail ever had any experience with."

"I am already noticing some tilt-brim flutter of the sail," said James. "It is easily damped out by the actuators."

"Just don't get careless," warned Jinjur. "The last thing I want to do is spend the rest of my life under an umbrella with a tear in it."

Jinjur padded to the science consoles and looked over the shoulders of the planetologists, Sam Houston and Richard Redwing, as they busily ordered the various image sensors into operation. She had to hoist her chunky body up onto her velcro-tipped toes to see, since both men were over two meters tall. Mechanical sounds came from the center of the control deck as different sensors emerged from their storage places, took turns looking out the Barnardside science dome at the nearby planets, then retracted back into their niches.

"How does it look?" she asked.

"The visible and infrared images are excellent," said Sam. "But the X-ray and gamma-ray images are blurred by the atmosphere. Also, the radio images show nothing but modest temperature variations. There don't seem to be any radiation belts, which means a low magnetic field."

"Does that mean there's no shielding

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from cosmic rays?'' asked Jinjur, slightly concerned.

''Nothing to worry about,'' said Sam. ''Although the atmospheric pressure is only about 20% of Earth's, the gravity is lower, so the scale height is much higher. There's a deep blanket of air to stop the cosmic rays. In fact, it's so thick that the two planets share a common atmosphere.''

''I think we'll be able to fly from one lobe to another in the *Dragonfly* aerospace plane without having to switch to rocket propulsion,'' said Richard.

''That doesn't sound right to me,'' said Jinjur. ''Aren't they a couple of hundred kilometers apart? Increased scale height or no, there isn't going to be much atmosphere left at those altitudes.''

''The gap is only 80 kilometers,'' replied Richard. ''And don't forget that the gravity drops to zero between the two planets, so the 'gravitational' altitude there is different than the physical altitude.''

''What a weird planet,'' said Jinjur. ''What else have you learned?''

''Why don't you show her some of the pictures?'' said Sam. ''I'll keep the science sensors going.''

Richard flashed some images across his screen in rapid succession and stopped at a picture that showed the two lobes fully illuminated.

''This is the best shot that shows the egg-shaped tidal distortion of the two lobes,'' said Richard. ''That particular shape was first calculated in the 1880s by a French mathematician named E. W. Roche. That's why this system got the name Rocheworld. He was primarily interested in the shapes of two closely spaced binary stars. I'm sure he never thought that there'd be a binary planet named after him.''

He switched to a close-up picture of one of the lobes. It showed a mountainous region with deep valleys.

''Sure looks rocky,'' said Jinjur.

''That's why this lobe of Rocheworld is called the 'Roche' lobe,'' said Richard. It just happens that the word 'roche' means 'rock' in French.''

''How come the valleys are all going the same way?'' asked Jinjur.

''That's the rift valley region,'' said Richard. ''Let me get another version.''

The screen flickered some more and finally stopped with a close-up picture of a large conical mountain peak with a rounded top and 60-degree slopes.

''That's the pointy part of the Roche egg,'' said Richard. ''The mountain peak is a part of the original Roche sphere that was pulled up into this shape as the two planets slowly came toward each other due to tidal friction. Sam and I expect that the rift valleys were formed at that time, with the 'stretch marks' in rings where the material was pulled up.

''What we don't understand are the deep valleys going 'downhill.' They look almost like river valleys, but they're completely dry. That'll be one of the first things we want to look at when we land there.''

''What's that fuzzy thing there on the side of the mountain?'' she asked.

''That's a volcano,'' said Richard. ''You'd expect a lot of tectonic activity in a region under as much stress as that one. Here, let me get some action in the picture.'' He punched a few keys and the picture was replaced by a 12-image stop-motion replay of the eruption of

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two volcanos to each side of the conical mountain. The plumes blossomed straight out from the sides.

"How come the plumes don't fall downhill?" said Jinjur.

"That's one of the strangest things about the shapes that the Roche mathematics predicts," said Richard. "The surface of that conical mountain with its 60-degree slopes is all at the same gravitational potential, even though the shape is not a sphere. The same goes for the other lobe, where the mountain is made of water."

Richard switched to another image. There was the same conical shape, but Jinjur could tell from the color and smoothness that it was the surface of an ocean.

"This is the wet lobe," said Richard. "It's named the Eau lobe, since *l'eau* means water in French. The shape of the Eau lobe is almost identical to that of the Roche lobe, except that its surface is almost completely covered with a water-ammonia ocean. The ocean is shallow on the outer portion of the lobe, because we can see some crater rims and mountain peaks showing through, while on the inner portion the ocean gets much deeper because it is pulled up into a mountain by the gravitational attraction of its twin."

"It looks like it ought to fall down," said Jinjur.

"What's even more remarkable is that the gravity at the top of the mountain is only a half-percent of an Earth gravity, while at the base of the mountain the gravity rises to a tenth of a gee. This is one time when you have to forget your long-taught prejudices about the behavior of water under gravity and believe the mathematics. The surface of that water mountain is all at the same gravitational potential, and the water is just seeking its natural level. The mountain doesn't just stand there looking impossible, though. There's plenty of action. Let me show you the movie that Sam and I put together. Roll it, James."

As the double planets rotated about each other each six hours, the tides and heat generated by Barnard pushed the ocean and atmosphere around. Each half-rotation, the water mountain would drop 20 kilometers, then rise again, driven by the tides. The atmosphere, meanwhile, driven by a combination of tides and heat, sloshed back and forth once per revolution. When the water mountain was rising and the atmosphere was going from Roche to Eau, the peak of water would be strangely calm, with only small breakers showing at its base, for the air was rushing down the slopes. Three hours later, the wind would be blowing up along the rising slopes of water. As the wind moved upward, it drove the water ahead of it. The wind-driven swells moved toward the peak, where the gravitation was weaker and the surface area smaller. The energy in the wave motion was concentrated into a smaller area, and with less gravity to keep the wave amplitude down the swells grew into waves that reached hundreds of meters in height as the gravitation and the available surface area dropped to nearly zero at the same time. The ring-waves climbing up the mountain became larger and larger and finally met in a ring-geyser that shot a fountain of foamy water up toward the zero-gravity point between the planets. There the geyser dissolved into a spray of water

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vapor, some of which drifted across the zero-gravity point to spawn tornadoes and thunderheads over the Roche lobe. The clouds dropped rain which dried to salt-specks before it reached the rocky surface below.

"A lovely place," remarked Jinjur. "Shall we drop in for a visit?"

"Yes!" said Sam. "Drop us down right on the equator of the rocky one. That's far enough from the tornado belt that the lander won't be disturbed, and I can poke around in the rocks while you flyboys and girls go fishing on the other lobe."

"This planet is the dream of an astrodynamicist," said Thomas. "I'd like to 'bug' it all over before we go down for a close look, especially the Lagrange points. They're very sensitive to orbital perturbations."

"I thought you only had Lagrange minima when one mass is bigger than the other, like the Sun and Jupiter," said Jinjur.

"They're much more stable then," said Thomas. "Especially the co-orbit points. But you get almost the same thing when the two masses are the same size. There's the obvious minimum where the gravity drops to zero between the two planets, then there're the famous L-4 and L-5 points, the only truly stable ones."

"Those I know about," said Jinjur. "They're always 60 degrees ahead or behind the planet in its orbit around the sun."

"In this system it's different," said Thomas. "Since the two planetoids are the same size, the Lagrange points are not at 60 degrees, but 90 degrees. That's where I want to put the communication satellites. The gravity minimum will keep them there with minimum fuel, and any perturbations will give my Roche-world computer-model some exercise. Perhaps we'll learn something."

"Will they be able to communicate well from there?" asked Jinjur.

"Two comsats at the L-4 and L-5 points will cover most of the two worlds except for the outer poles," said Thomas. "I propose to put another comsat in counter-orbit to their rotation so that we get frequent contact with any point on the two lobes."

"Fine," said Jinjur. "You and Gretchen go up the shaft, break them out, and transfer them to the lander."

Thomas headed for the 60-meter-long lift shaft that ran up the center of *Prometheus*. As the lift elevator was rising through the ceiling of the control deck, James jerked it to a halt just in time to prevent the edge of the lift from cutting the flying body of Gretchen in two as she streaked to join Thomas on the doughnut-shaped platform of the lift.

"Gretchen," said James in a dry voice.

"Don't try that 'tired Butler' voice on me, James," said Gretchen. "I designed you with plenty of safety margin in the lift elevator. I merely used a little of that margin for my last dive. Up we go!"

The lift started again and went up through the ceiling to level 44. There, three comsats, Clete, Walter, and Barbara, were activated and carried to the hydroponics deck. The humans with their robotic load entered the humid green world of waterfilled walls and made their way down one of the short cross-corridors to a porthole in the ceil-

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ing that led to one of the four Surface Landing & Ascent Modules that *Prometheus* carried. The porthole was open, and Thomas looked up to see the innards of SLAM I and the flashing green limbs and short red hair of a busy heavy-lift pilot strapped into an acceleration harness, checking out a long-dormant, sleeping giant of a rocket. Crouching low, Thomas launched himself through the porthole overhead. Securing himself, he reached down to take one of the comsats from Gretchen.

As Gretchen stored the comsats away, Thomas went over to talk to Elizabeth "Red" Vengeance, hanging upside down in the blue pilot harness. Elizabeth looked up from the console.

"I've found one malfunction and three 'out of spec' indicators in the countdown list, and they're all on outside sensors," she said. "I was going to send the Christmas Branch out to investigate, but why don't you do it?"

Red busied herself at the console while Thomas made his way upward from the bridge deck of the SLAM and through the pristine but cramped crew quarters deck to the 'bottom' deck. Everything was upside down from what it would be once the SLAM were under acceleration or sitting on one of the planetoids of the Barnard system. He put on a suit, then went to the side air lock and punched some keys built into the wall next to the door. A strange, yet familiar, computer voice spoke to him. It was Jack, James's alter ego for the computer in the SLAM.

"I can have the Christmas sub-branch assigned to this lander make the inspection," said Jack.

"They taught me in flight school to

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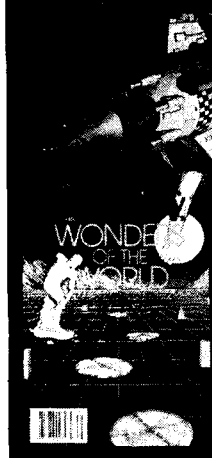

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always check out my plane personally before I fly," said Thomas. The door hissed open and he stepped in on the ceiling of the air lock. After some pumping noises, his suit ballooned out and the outer door swung open. The strange accent of Jack spoke through the computer imp in his suit.

"Don't forget James has *Prometheus* under acceleration. Please use your safety lines," said Jack.

"Right," said Thomas, fastening a hook into a nearby ring and stepping out. He activated his 'stiction boots and moved along the curved hull of the massive rocket. He worried a little about the stability of the forty-year-old fuel under his feet, but there was little he could do about it now, for the nearest fuel depot was six light-years away. He marched down the hull in the low acceleration to the 'top' of the SLAM to check out the errant sensor modules.

"Three tired solid-state detectors and one micro-meteorite strike," said Thomas to Red Vengeance as he took off his helmet and handed it to Gretchen. "I upped the voltage on the detectors and they're back in spec, and the Christmas Bush sent out a branch with a replacement for the punctured unit."

The lander soon filled up with its crew, who were busy shifting their personal belongings from their luxurious apartments on *Prometheus* to the crowded vertical beds they would be using while the SLAM was in free fall. A few days passed, the checkout was completed, and it was time to go. Jinjur escorted George Gudunov to the lock between SLAM I and *Prometheus*.

"I wish I were going down," said Jinjur.

"I thought you never wanted to see dirt again," said George. "Especially if it had gees holding it down."

"It's only 10% Earth gravity," said Jinjur. "Besides," she said wistfully, "it's been 44 years."

"Doesn't time fly when you're mentally incompetent," said George. "Okay. Next planet you get to go down with the exploration crew and I stay at home minding the ship. See you in a few months."

"Take your time and do it right," said Jinjur. "We have the rest of our lives for exploring, but only four landers."

"See you soon," he said, and closed the airlock door, making sure it was space-sealed.

"We're ready to go, Jack," he said to his imp. He heard pumps working and the outer lock door creaked slightly as the air in the small volume between the SLAM and *Prometheus* was pumped out. George's personal imp jumped off his shoulder to the door and searched the seams for any sign of leakage. Finding none, it jumped back to his shoulder. For a few seconds George felt both naked and bereft, for it was the first time in over four decades that his personal imp had left its perch on his shoulder. James could afford the luxury of a lock-imp on *Prometheus*. Life would be more spartan for Jack's landing crew.

George cycled through. Gretchen Krupp was waiting for him, standing on the ceiling. She and Jack's Christmas Branch double-checked the docking airlock, then Gretchen turned to check out the many instruments on the science consoles. She was apparently able to read the labels and indicators as easily

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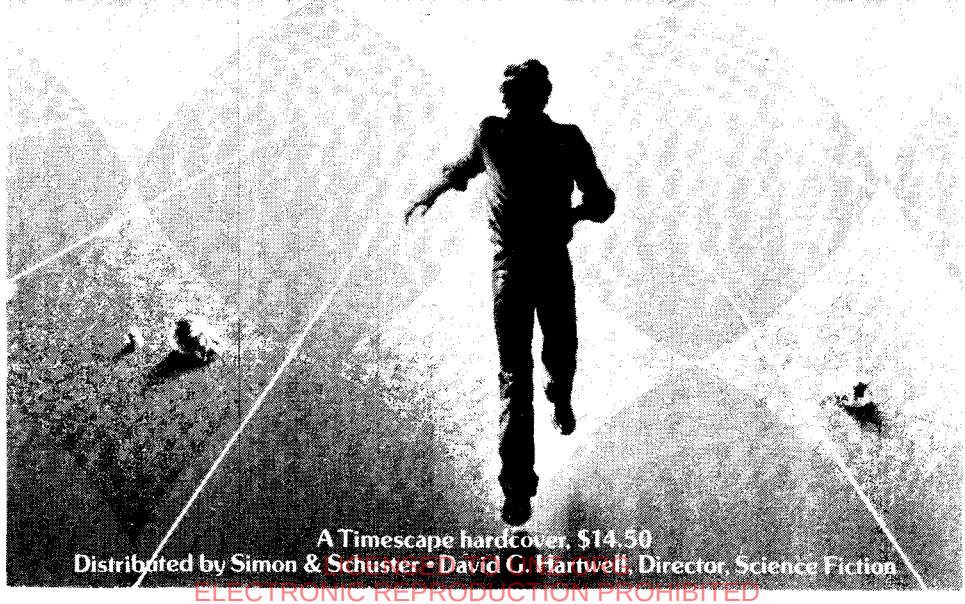

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upside-down as rightside-up. George paused at the wedge-shaped passway through to the next deck, and holding onto the ladder rungs welded into the consumables column that ran through the center of the ship, he looked up to see Arielle, Richard, and Sam busy stuffing equipment and supplies into the storage bins next to the galley.

"Breakaway in five minutes," he warned.

"We'll be ready," answered Sam.

George continued around the central column, walking on the ceiling of the bridge. Carefully avoiding the large glass docking window at his feet, he nodded at Thomas St. Thomas and Red Vengeance, who were buckled into the blue and red pilot and co-pilot harnesses in front of their consoles, then continued on to the computer and communication consoles.

"Jack is ready," said David Greystoke up at George. Like the two pilots, he was hanging from the floor in a green zero-gee harness.

"*Prometheus* has given us clearance for breakaway," said Gretchen from the console next to David's.

"Take her away, Captain St. Thomas," said George.

Thomas grasped the controls and nodded at Red. She flicked a red switch cover and threw the switch that had been protected underneath. There was a loud clunk from the docking port overhead, followed by a series of clattering ripples as the clamps that had held SLAM I to the outside of the lift shaft on *Prometheus* were retracted. Nothing happened, for they were still held to the sailship by its acceleration.

Thomas pushed a control forward and the bridge crew hanging from the ceiling sagged a little deeper in their harnesses as the acceleration increased. Thomas and Red looked out their docking port window as the huge cylinder tilted and swung out from its cradle on the light ship. As soon as the edge of the hydroponics deck on *Prometheus* had been cleared, Thomas switched to other control jets and slowly flew the ponderous cylinder out through the shrouds and away from the sail.

"The *Eagle* has left its nest," said George to his imp.

"Good hunting, *Eagle*," said Jinjur's voice.

As soon as Thomas had pulled them away from their berth and out from between the shrouds, he turned off the maneuvering jets and they were in free fall. Suddenly George felt upside-down and quickly floated around to point the same way as the rest of the crew.

"This sure is easier than trying to leave a tumbling asteroid," said Red, as she watched out the docking port at the slowly twirling lightsail and its cylindrical payload with the wedge-shaped gap in one side.

"All we have to do is stay cool and float, while the starlight pushes it out of our way," said Thomas.

After about an hour *Prometheus* was 20 kilometers away. Using low thrust from the main rockets, Thomas steered the *Eagle* away from the sail and into a rendezvous orbit with Rocheworld.

For two days they spiraled in from orbit, letting Jack get used to the strange double-lobed rotating gravitational field and taking detailed close-up pictures of their planned landing place.

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"Looks just like Mars," said Sam to Richard.

"With fewer boulders," said Richard as he blew up the picture on the screen until he could see the pixels. "Looks like it's been swept clean. We could land just about anywhere with no trouble."

"Why don't we make it by this mesa," said Sam. "That 10-meter scarp should give us a good cross-section of the crust for a first look."

"Looks like the edge of a streambed."

"So do a lot of features on Mars," said Sam. "But all those streams flowed millions of years ago, and the waters that flowed dried up and went away. Here there was probably a lot of action when the Gargantuan moon and the interloper first interacted, but since Eau is some 40 kilometers smaller than Roche, it's just that it rained more on the lowlands than up in the Roche mountain plateau, and all the water ended up on Eau. My guess is that those stream beds are as old, if not older, than the ones on Mars."

"The only way to find out is to go down and count craters," said Richard. "But don't you want to land on the mesa, just in case?"

"Then my excursions on the dirt-buggy will be limited to the mesa," said Sam. "And I plan to take longer trips than that. The stream-bed near the cliff, Jack."

"I will inform Captain St. Thomas," said Jack.

Eagle approached Rocheworld in the ecliptic plane, but going in the opposite direction to the spin of the planetoids. As they moved closer and closer, the orbital track on Red's console took on a wavy appearance as the two lobes pulled the track this way and that.

"Having any navigation problems, Jack?" she asked her imp.

"Newton's laws are still valid, Elizabeth, even though it may not look like it on the track replay. I do have to carry the calculations a little farther than normal before I truncate the series, though."

"I'm glad you're doing this and not me," said Red. "Intuition can get you in trouble this close to those whirling dervishes."

"Intuition has served humans well," said Jack. "It is their strongest point as a computational system. Like most strengths, however, it is also one of their weakest points."

Thomas overheard the exchange.

"Don't feel bad, Red," he said. "I think you're the cutest computational system I've ever seen."

Red smiled and somehow felt a lot better.

"It's time to release Barbara," said Jack.

"I'll get her," said Gretchen, who had been floating around the deck with little to do. She pulled herself over to one side of the bridge and opened a storage locker.

"I'd appreciate a hand out of here," said a contralto voice through Gretchen's imp.

Gretchen grasped the communications satellite carefully at the base of its antenna and pulled it free from its fasteners. She nudged the heavy spacecraft around the bend to the docking port entrance. Jack checked out the lock and Gretchen opened the door. Carefully she inserted the comsat in the exact center

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of the lock, careful that its folded antennas would clear the outer door.

"Keep in touch, Barbara," she said.

"That's my job."

Gretchen closed the door to the docking lock, then went around the central column and nodded at Red, who had moved to the pilot position. Red had fastened herself into the blue safety harness even though the planned accelerations would be negligible.

Red watched the orbital track until the wavy track had neared its minimum, then her finger gave a slight nudge to a button on her control stick. Gretchen felt a slight tug on the sticky patches of her corridor boots.

Nicely done, she thought. *It's those years in the asteroid belt.*

The velocity difference imparted by the tiny flare of control jets was small, but a minute later Gretchen could see Barbara slowly rise up out of the docking port without a single trace of spin or tumble. When the comsat was about 10 meters away, Gretchen sent it a message.

"You may fire jets when ready, Barbara."

There was a burst of tiny jets as the spacecraft rotated its orientation, then a larger burst as the comsat took off to take up its station in an orbit that rotated in an opposite direction to that of the two planetoids. That way it would pass over each outer pole twice each rotation so that no point would be out of sight of a comsat for more that three hours.

"This is Barbara, signing off," said the comsat as it flew out of sight.

With the comsat launched in its counter-rotating orbit, Red expertly rotated the huge cylinder end over end. As the spacecraft rotated to a halt, Red talked to her imp.

"Announce imminent gees to all hands, Jack," she said.

"Thrust will commence in one minute," boomed Jack's voice throughout the ship.

The period of thrust lasted for fifteen minutes. The tilt of the spacecraft came back to horizontal as the rotation of the lobes slowed and stopped until they were stationary. Barnard was in the sky, and the two lobes were brilliantly lit with a flat red glow.

"L-4, Gretchen," said Red's voice through the communication imp. "Time to dump Clete off."

Gretchen left her seat in front of the viewport on the deck below and floated her way back through the galley and up the passway to the storage locker.

"L-4, Clete," said Gretchen.

"Jack so informed me, Miss Krupp," said Clete through her imp. "If I might trouble you?"

"No trouble at all," said Gretchen, taking the heavy satellite out of the locker and pushing it through the free-fall air to the docking port. "Just part of the taxi service."

She cycled the lock and went back to watch Red do another of her minimal bursts.

"You're on the up cycle, Clete," said Gretchen. "Keep bouncing so we can see you at the cold poles."

"This is Clete, signing off," replied the comsat.

"Let's take a break before we insert the last one," said Thomas to Red.

"Let me move *Eagle* to the inside first," said Red. "With Clete bouncing up and down through the L-4 point, we

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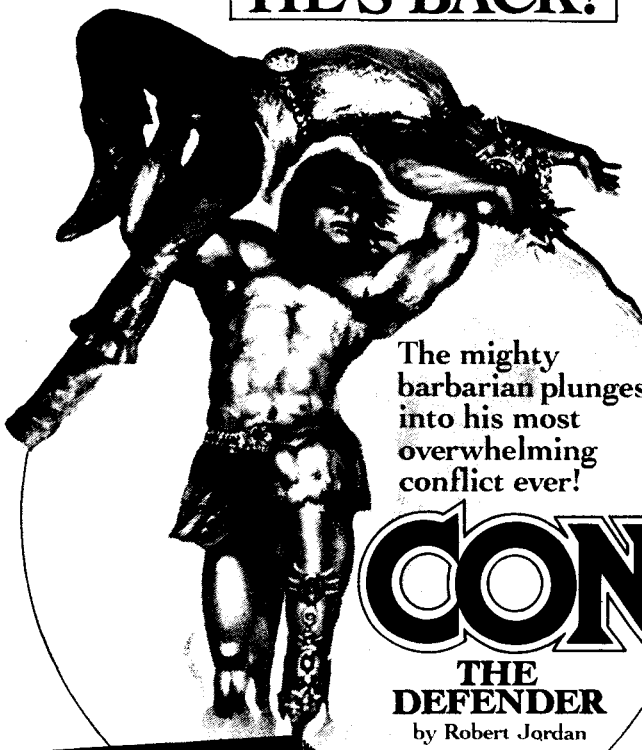
HE'S BACK!



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don't want to be in the way when it comes back down." She fired a burst from the attitude jets, then turned the controls over to Jack.

"Give Thomas and me a call in eight hours, Jack. We're going to rack up a few winks."

Eagle's two pilots snaked their way down through the passway, and George's grey thatch appeared in the wedge as soon as they left.

"Since it's going to be quiet for a while, Gretchen, I thought you, Arielle, and I could check out *Dragonfly*."

"I'd like David along, too," said Gretchen, as she swam to the passway and ottered through.

"Are you sure the seals are okay, Jack?" said Gretchen. "Shouldn't I wear a suit for the first time?"

"I have imps inside both the lock and the boarding port," said Jack through her imp.

"I'll still suit up and go first," said Gretchen gruffly. She pulled open the suit locker and got out her suit. "Here, George," she said, handing him her helmet. "Check me out."

"Sure, Gretchen. Sure," said George, helping her with a sleeve. For someone who could put a suit on with her eyes closed, she was now awkward and clumsy.

David looked at George and then Arielle, who was trying to pretend she wasn't there. David finally put in his oar.

"Gretchen," he said. "Stop being mad at yourself just 'cause you're cautious. You're not being too fussy about safety. Just do your job, and do it right. We're in no hurry. The last thing we want to lose is *you*."

Gretchen stopped in mid-jerk on a zipper. She took control of herself, and the rest of the suiting took place in record time. In her full spacesuit, she went through the first door of the airlock that would take them to the cockpit entrance of *Dragonfly*. The door closed and George listened to her through his imp.

"Boarding port pressurized?" Gretchen asked Jack.

"My imp there reports so," replied Jack.

"Open the door," said Gretchen. George could hear some mechanical noises through the wall, but there was no sound of air escape. He peered through the porthole in the door and saw Gretchen pull a cloth wiper from her thigh pocket and wave it in front of the seal surrounding the fuselage of the aerospace plane. After a while he saw her crack her helmet back on and reseal it. Then she went to the door built into the co-pilot side of the *Dragonfly* and, lifting panels, pushed the door inward. She cracked her helmet once again and stuck her head in to look down the long corridor. She floated back out, put her helmet back on and sealed it, then carefully closing and sealing each door she had opened, made her way back into the *Eagle* through the airlock.

"I think it's safe to go in without suits," she said. She was sure, now that she had checked personally. She made her way to the suit-locker, shaking off George's offer of help, while Arielle, David, and George cycled through and floated without suits through the narrow co-pilot hatch into the magical realm of the aerospace plane—*Dragonfly*. Arielle was the first through the hatch.

"Hello, Arielle," said Jill's beautiful

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soprano voice. "I'm glad to see you again. Is Rocheworld as interesting to fly in as Titan?"

"Ho!" said Arielle. "It is much interesting. We can go very high there. There are lots of thermals and we can *fly* from Roche to l'Eau."

"Jack says that we won't even need rocket assist," said Jill. "That's good. I'd much prefer to always keep that for emergencies. I do so hate to use up my consumables."

David swam in through the lock, all business.

"Self-check routine zero," he commanded.

"7613FF," said a mechanical voice through his imp.

"Check," said Jack.

David consulted a printed checklist and nodded agreement.

"Self-check routine one."

"Surface Excursion Module One going through systems check," reported Jill's beautiful voice. There was a long pause. During the wait, Arielle and David were joined by George and Gretchen.

"Five sensors out of spec, two tanks with measurable level of degradation contaminants, and a missing flask in the galley," Jill finally reported.

"This one?" said Arielle. "I was going to fix me a shake."

"Wait till after checkout!" exploded Gretchen. "Right now Jill is too busy."

"Oh. That's why we no have algae-shakes." Arielle put the flask back and swam up the length of the corridor to join George on the flight deck. They took Jill through a few simulated landings, while Gretchen, back on the engineering console, inserted a few "emergencies" to keep them all in practice.

"That's enough," said George, after he had botched an engine-out landing and Arielle had intervened at the last second with a blast from the space thrusters to float them to a stop. "Jill looks in good shape, and it's time for Thomas and Red to pull gees to arc over to L-5 and dump Walter. Let's seal up *Dragonfly* and get some dinner."

"I'll be there later," said Gretchen. "Have to check out those low sensor readings and the impurity reports."

"I be glad to eat your dinner for you," said Arielle as she unbuckled and flew out the hatch.

"You just leave my dinner alone," shouted Gretchen after her. ". . . you skinny bottomless pit!!"

After dinner Thomas and Red went upstairs to the bridge, with Gretchen following to monitor the systems on the engineering console. The rest of the crew gathered in the lounge to watch the scene out the viewport and to settle their meals in the acceleration.

"Shall I take the co-pilot harness?" asked Red, as they made their way up the passway.

"Nope," said Thomas. "I may be good at up and down, but for the roundy-rounds, you're the pro. You get the blue harness and I'll watch and see how you do it."

Eagle was in a synchronous orbit about Rocheworld. To move from the L-4 point to the L-5 point, Red decided to bounce up out of the plane of rotation far enough so that when they came back down, Rocheworld had slipped in an extra half-rotation on them. She tilted the *Eagle* and initiated thrust in the main

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rockets. The viewers in the lounge on the deck below sank into their seats as the tilted scene slowly rotated in the viewport. Darkness set on Eau as Roche blocked the sun. They looked down at the northern cold poles as the sun rose again on Eau. Large circular storms could be seen on the cold crescent as a snow of water and ammonia rained down on the mountain of water. They came to a halt at L-5, where Walter was dispatched in a bouncing orbit that alternated with that of Clete. Now, like the outer poles, neither cold pole was more than three hours away from a comsat. As they were dumping Walter, Barbara came zipping past in its counter-rotating orbit.

"This is Barbara checking, one . . . two . . . three . . ."

"We hear you fine, Barbara," replied Gretchen.

"This is Barbara, saying goodnight," said the comsat as it dipped into the darkness behind Roche.

Thomas and Red went down to confer with George.

"We've only been up four hours," said Thomas. "And Red did all the work on that last one, while I just dozed away in the red harness. We can take it down if you want us to."

"What's your recommendation, Jack?" said George. He noticed Thomas and Red's computer imps spread their wiry fingers on the necks and jugular veins of their charges, scanning their vital signs.

"I have no objection," said Jack.

George's imp vibrated with a voice that he had not heard in some while. "James sees no problem either," said Jinjur.

"Take her down," said George. Thomas and Red turned and snaked their way back up the passway. George followed, and the other crew members either went to their racks or to their stations, as they prepared for a landing on Rocheworld.

"Stand by for deorbit burn," said Thomas. "This'll be the most gees you'll have felt for decades, so make sure you're fastened down."

Slowly Thomas pushed forward on the throttle to the main rockets. He and the rest of the bridge crew sank in their harnesses, while uncomfortable groans were heard from below decks.

"That's only a half-gee," said Thomas with a grin. "We go to three gees just before reentry."

The rocket engines blasted a powerful glare over the darkened planetscape below, then throttled down to a more controlled thrust as the huge cylinder floated down through the miles of atmosphere, letting the friction of the cold thin air do its work in dissipating the energy of the falling eighty tons of matter.

A quiescent blob of milky white jelly rested in the dark ocean of Eau. Clear`White`Whistle, an expert surfer, had ridden the last ring wave all the way up the water mountain. It had stayed poised on the face of the wave, halfway between a forced dive and a forced tumble, for nearly an eight of a rotation, while the others of the pod had fallen off along the way. Roaring*Hot*Vermillion, usually the best surfer of the pod, went too far up a wave in an attempt to outdistance the rest at the beginning of the run and had been broken into three parts and foamed-out right at

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the start. Warm@Amber@ Resonance and Bitter#Green#Fizz had been with them, but they too finally had to take a forced dive, leaving Clear`White` Whistle to navigate the last half of the mountain on the side of a wave that was bigger than many of the rocky ridges on the bottom of the ocean.

It had been thrilling to be surfing along at speeds that were so high that the sonic pings returning from the lower scattering layers had shrieked into the upper register. The fun was over and it was time to think. Time to think deeply and clearly. Clear`White`Whistle often wondered about the type of thinking it did. Most of the others in the pod, and indeed most of the others in the ocean, were all the same in their thinking. Numbers, mostly. Some about arrays of numbers. Some about all the numbers between Oh and One. Some about the numbers that were not numbers but could be.

Clear`White`Whistle felt alone. It knew all about numbers—enough to do that kind of research itself. But it wasn't content with that. The numbers had to mean something. It felt exultant and perverted as it tried to impale the numbers on the lights in the sky.

Clear`White`Whistle searched the water around it. It could see nothing except the rocky bottom far, far below. Secure in the knowledge that it could not be seen, yet still secretive, it raised an appendage of thick milky-white jelly. The end floated in the water above the central part of its body. By concentrating, it caused the end of the appendage to become thicker and disk-shaped, but it remained milky white like the rest of the appendage. Then, fighting the sexual joy, yet reveling in the perverted self-gratification, Clear`White`Whistle seductively extracted its white from the clear gelatin lens floating on the smooth surface of the calm ocean mountain. The milky body below the surface adjusted its shape until the spots of light on its surface were of minimum size. Like Galileo, gazing on the proscribed heavenly spheres, Clear`White`Whistle returned to its solitary study of the stars.

Clear`White`Whistle had given the red glare of Hot the number Oh. The bright red light seemingly burned into the white flesh. Oh was flanked this rising by a pattern of smaller dots, numbered 6, 32, and 47, while Warm — number One—was still hidden in back of the ocean. Warm would make an appearance soon, and Clear`White`Whistle resolved to wait for it.

Meanwhile, the positions of all the rest of the numbers in the sky were measured and compared against its memory. None had changed over the many seasons since it had first looked at the sky except perhaps for a slight shift in the yellow point of light at the end of the straight string of low-numbered lights.

Clear`White`Whistle had been studying the points of light whenever it had some time off to itself. In this period it again puzzled over the behavior of the light numbers. Most of them were simple. They could be handled by a simple coordinate transformation, since they never changed their relative position. However, the mathematics of One and its higher-number lights was nearly impossible. For a long while, One wandered about in the sky like a broken

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flitter. Then, every 480 rotations of the sky, it got brighter and brighter until it looked as if it were going to rival Oh in the sky.

Clear`White`Whistle thought that it knew all the light numbers. This time, however, there was a new light in the sky. It varied rapidly and moved downward toward Sky:Rock until it disappeared on the Hot-limned side of the rock. It moved much more slowly than the other specks of transient light that Clear`White`Whistle had occasionally seen at the dark times. Perhaps the brighter the falling specks were, the slower they fall. Yet that thought didn't really satisfy Clear`White`Whistle. It very much wanted to know the logic by which the specks of light in the sky moved, especially the motions of One and its smaller lights, but the form of the mathematical rule eluded its most concentrated thought.

The ponderous, top-heavy bulk of the rocket-ship *Eagle* drifted slowly downward on a rippling flame of rocket exhaust. The crew-members left back on distant *Prometheus* were gathered at videos and consoles, monitoring the landing on Roche through the quartet of video cameras looking down from the sides of the lander. The lander was drifting inward as Thomas looked for a good landing site. He peered down at the ground in front of him as he maneuvered the controls, while Red watched all four video scenes on her split-screen display and Jack kept up a running commentary through their imps.

"200 meters . . . four-and-a-half down . . . kicking up some dust . . . four forward . . . drifting to the right a little . . . contact light . . . engine stop. . . ."

There was a pause. Then the lightsail crew burst into cheers as Thomas's exultant voice came through strong and loud.

"*Prometheus*! Rocheworld Base here. The *Eagle* has landed!"

George let out his breath. For safety he and the crew members who weren't actively involved in the landing had strapped themselves into their bunks. He hung uncomfortably in his vertical sleeping rack in the 10% gravity, his feet not quite touching the deck. As he unfastened the straps, he could hear thuds from the cubicles around him as the rest of the crew left their sleeping racks and filed down the narrow corridor to the rest of the ship. Most made their way to the miniature lounge and crowded around the viewport to look out at the alien scenery. George clumped his way up the ladder through the passway and went over to congratulate Thomas.

"A fine landing," he said, helping Thomas with a recalcitrant fastener on his harness.

"Couldn't have done better myself," added Red, who was still busy powering down the landing systems and readying the Ascent module for lift-off in case they ran into any trouble.

"Why thanks, Red," said Thomas, a pleased smile on his face. "Those are high words of praise from an old torch pilot like you."

Red glanced at him with an annoyed expression. "I'd prefer the phrase 'experienced' rather than 'old,' sonny boy," she said. Then she added eagerly, "But I'll forgive you if you let me land the next one."

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"It's a deal," agreed Thomas, glad to have gotten out of his gaffe so easily.

"How's the atmosphere, Jack?" asked Gretchen. "Can we imitate Buck Rogers and throw off our helmets after a precautionary sniff and run through the meadows in bare feet with the wind blowing through our hair?"

"I'm afraid not," said Jack through her imp. "My analyzer only confirms what we measured from orbit. An atmosphere of methane, ammonia, water vapor, and hydrogen is definitely poisonous all by itself, not to mention the trace amounts of hydrogen sulfide and cyanide gas that my analyzer can pick up now that we are here."

"Hydrogen sulfide?" said Gretchen. "That's going to make for a stinky airlock even after purging."

"You won't notice it," said Sam. "Your nostrils will be anesthetized by the traces of ammonia."

"My locks have been designed with minimal trapped volumes," said Jack. "After pumping down to vacuum, then flushing with air before the final cycle, I should be able to keep the amount of ammonia, hydrogen sulfide, and hydrogen cyanide released into the ship at low levels. Unless you have a very sensitive nose, you won't notice it."

"I *have* a sensitive nose," said Gretchen. "It's an engineer's best tool."

"I'm ready to go out," said Sam. "I want to get a look at this geology around here. Is it okay if I suit up?"

"If it's okay with Jack, then it's okay with me," said Gretchen. "But aren't you forgetting protocol? The commander of the ship gets to be the first one to set foot on the new planet."

"You're right," said Sam. "If it hadn't been for George suggesting the first Barnard lightsail probe mission, we wouldn't be here. He gets to go first, but I wish he'd hurry up."

"I'm coming," said George, making his way down the passway ladder.

George went over to the suit locker and started dressing, with Gretchen and the Christmas Branch helping. Richard joined them.

"Why don't you and Richard get suited up too, Sam?" said George. "The lock should hold three of us with a little crowding, and there's no need to make this a dramatic one-man production."

The three men, meticulously checked out by a clucking Gretchen, cycled through the airlock and opened the outer door to look 36 meters down to the surface below.

"Looks like the high-desert regions in California," said Richard. "Dry, dusty, and windy."

"And bare," said George. "At least the high desert has a few cacti and scrub plants." Holding carefully onto the handrail aligned with the outer door, George stepped on the top rung of the "Jacob's ladder" and started down the 90 rungs to the bottom. Sam waited until George had made his way down a few meters, then followed after, his long joints having an easier time with the widely spaced rungs. Richard unfastened the winch I-beam from the ceiling of the airlock and swung the beam out through the door so the end of it hung two meters away from the side of the lander. He rolled the winch out until it reached the end of the beam, then fastened the hook on the end of the winch cable to his suit belt. He grabbed the

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cable and using it to hold himself vertical, he stepped off into the air.

"Lower me down," said Richard to his imp, and the winch started to pay out the cable, Richard twirling slowly about at the end. He passed by Sam, who had paused at the place where the ladder left the side of the ship and turned into steps on one of the landing struts. Richard had Jack halt the winch when he was still two meters from the surface. He had brought along a video camera to record George's first step off the landing pad onto the soil of Roche.

As he made his historic step off the landing pad, George looked toward Richard and the camera and started talking.

"This is but the first step on mankind's long journey . . . WATCH IT!!!"

He rushed over to catch Richard. Richard, both hands working the camera, had tried to hold himself upright on the cable by tucking it under one elbow. After capturing George's first step, he had panned up to get a picture of Sam on the landing leg. Top-heavy with the camera, he had lost his balance and toppled over, his helmet narrowly missing a boulder as he swung upside-down from the hook. George held Richard by the helmet.

"We almost lost you," said George in a soft voice. "If your helmet had cracked, you wouldn't have lasted a minute in this poisonous atmosphere."

Richard got up, his suit dusty from the dry soil.

"I'm sorry I messed up your speech," he said.

"That's all right," said George. "I wasn't really sure what I was going to say next anyway. I was thinking of '. . . mankind's long journey into the galaxy,' but that sort of puts a limit on mankind's explorations. I could also have said '. . . universe,' but by the time mankind has explored even this galaxy it will have evolved into something else, and to say that mankind will explore the universe is equivalent to saying that it was a crew of plankton who first landed on the moon."

"No plankton here, anyway," said Sam, taking a sample of the soil and chipping a chunk off the boulder that nearly got Richard. "Weathered igneous rock with lots of vesicles," he said to Richard, handing him the rock sample.

Richard glanced with a practiced geologist's eye at the sample of the rock that had nearly killed him, and then looked up the long mountain toward the inner pole of Roche. "There's plenty of volcanos up there to make it," he said. "I wonder how it got here?"

"Could have been a large eruption," said Sam. "The volcanos probably become more active at periapsis."

"Perhaps," said Richard. "After we've identified the source volcano, I'd like to do a simulation of the ejection and get some idea of the size of the eruption needed to throw it this far."

"Don't forget that the volcano is at a much lower gravity there than we are here and is erupting at a 60-degree angle due to the slope of the inner point. Intuition isn't much good on this planet. There's another rock over there; I think I'll get a sample from that one too."

As the two rock hounds took off, sniffing at rocks, cracks, and scarps, George looked up to see other suited figures making their way down the side

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of the ship. One was efficiently climbing down the rungs of the Jacob's ladder. That was obviously Gretchen. The second was helping a tiny one attach itself to the winch cable. The thin suit poised delicately in midair, then rode down to the surface.

"Like gliding!" said Arielle with an excited voice.

George helped Arielle unfasten the cable, and Jack rewound the winch for the next member of the crew.

"It's so desolate," said David as he landed. "Kilometers upon kilometers of nothing but rocks and sand. What a dreary place."

"Sam and Richard seem to find it interesting," said George, pointing out the two figures off in the distance. One had climbed halfway up the nearby scarp leading to the mesa and was obviously trying to chip a sample from a rock imbedded in a yellow-red layer there. The other one crawled into a small cave near the base and came back out, holding something in its gloved hand. It started walking back toward them.

The landscape was like the desolate maria of the moon back at home. The worn hills, the isolated rocks, torn from their distant moorings many ages ago by unknown forces. The dull grey-brown color of dust upon soil upon dirt upon gravel upon rock that was the heritage of every barren planet. Sam was familiar with this type of scenery. He had "cut his teeth" on it as a graduate student trained on the moon, and had learned to distinguish the zero atmosphere dust sills of the moon from the clinging globs of dirt on Mars without having to disturb either pristine ashheap shape. This planet (half-planet, he reminded himself) was like both in many ways. He approached the group at the base of the lander.

"Look what I found," said Sam. He held out what looked like a piece of molten orange glass.

"What a strange-looking rock," said Red. "I've never seen volcanic glass that color."

"It's not a normal glass," said Sam. "Watch!"

He put the end of the piece of orange glass on a boulder and hit it with his geologist's pick. The tip of the rock shattered into tiny bits like a piece of tempered glass. All the bits were identical and very tiny. The bits had two faceted ends connected by a thin waist. They were the size and shape of tiny ants.

"Let me see," said Gretchen, taking a few of them and holding them up to her helmet. "They look like orange-colored models of Rocheworld." She took a bag from her tool pouch and placed the bits on the rock into it.

"I think I'll take these in and have a look at them under a microscope while Jack does a chemical analysis. Perhaps that will give us a clue. We're too used to rocks that form either in vacuum or in Earth air. It could be this strange chemistry can produce material that crystallizes in such an odd form."

Later Gretchen called the crew together. "It's time to lower the *Dragonfly* to the surface and put its wings on. I want to get through the lowering phase before Barnard sets behind Roche."

"Do be careful!" said Arielle.

"We won't hurt your pet," said

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Gretchen. She walked around to the front of the lander and stood at the base of the landing strut that had been modified to act both as a leg for the lander and as a lowering rail for the nuclear-powered aerospace plane.

"Release holddown lugs, Jack," she said, then nodded in satisfaction as the claw-like devices swung clear. The aerospace plane shivered slightly as the hold on it was loosened, but it still hung vertically from its nose hook.

Gretchen stepped to one side and looked up the belly of the plane to the top.

"Lower top winch!" she called, and slowly the nose of the airplane tilted away from the lander, the tail staying in place at the top of the lowering rail. Gretchen could now see the cockpit windows and the large triangular gap in the side of the lander as the plane pulled away from the side of the ship. The rotation continued until the airplane was leaning away from the lander at an angle of about 30 degrees.

"Now both winches!" said Gretchen. Jack started the bottom winch, and letting out both the nose cable and the tail cable at the same speed, it lowered the aerospace plane slowly down the lowering rail, still at the 30 degree angle. As the plane moved down the rail, the tall rudder on the plane finally cleared the side of the lander. About two meters from the end of the rail the tail winch stopped, while the upper nose winch continued to pay out cable. Slowly the huge plane rotated about the pivot point near the tail. As it approached the horizontal, there was a noticeable tilt to the lander as it reacted to the weight of the plane with its heavy nuclear power plant in the rear.

"Lower landing skids!" said Gretchen, and slots appeared in the belly of the aerospace plane. Three skids came out. They reached to within a half meter of the surface.

"Lower her down!" said Gretchen, bending down to watch underneath. Slowly the plane was lowered to the surface.

"Done!" she yelled, then raced to detach the lowering cables from the front and rear of the aerospace plane. The winches retrieved their cables, their job done.

"Just in time, too," said George, as the sky reddened to a deeper color than the normal illumination. "Looks like a beautiful sunset tonight. Let's get everybody back on board before it gets too dark. The ladder and winch are tricky at night."

"If you please?" said a small voice through his imp. "I like to sleep on *Dragonfly* tonight."

"Oh," said George, "Sure, Arielle, if you want to. Won't you be lonely?"

"I'll stay too," said David. "We both have a lot to go over with Jill."

"I get to add their sleeping space to mine!" hollered Sam, heading at high speed up the Jacob's ladder.

"Just one," yelled Gretchen after him. "I get the other one."

After rearranging the bunk partitions to give himself a little more room, Sam went up the passway to see how Gretchen was doing with her analysis of the bits of orange glass.

"Hello, Sam," she said, as his head appeared above the floor of the bridge and the rest of his long body continued

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its upward rise. "I've got one of the bits under a microscope. Want to take a look at it?" She moved aside, and Sam bent over to peer through the eye-piece.

"The central waist has four sides," said Sam.

"Yes, there is a central crystal that is four-sided. Strange enough in itself, but the faceted balls at the end seem to be of the same material, as if it decided to switch to a more complex crystal form. The basic material is clear. Jack is still working on the chemistry, but it is a very complex molecule similar to the silica gel crystals that are used to keep things dry. Like silica gel, it's highly hygroscopic. I put one in water and it puffed up to double its size, became soft and gel-like, then fell apart. The orange color comes from a very thin surface layer that doesn't penetrate into the interior and scrapes off quite easily."

"Could it be a life-form?" asked Sam.

"I doubt it," said Gretchen. "It's not complicated enough for its size. Besides, what would it eat? So far, Jack has found no evidence for smaller life forms such as bacteria. I'm sure it's just a strange crystal type."

"Okay," said Sam, rising from the microscope. "But I'll keep an eye out for more samples. I think I'll go to bed. It's been a busy day."

It was their first night on the new planet. George and Sam, the "old folks," had gone to bed. The activity on the ship slowed and the remainder of the crew gathered in the lounge, snuggled close together. They looked out from the 40-meter height advantage of the viewport window along the long slopes of the conical inner pole that stretched out toward the distant globe of Eau, hanging above them in the sky. The shadow of Roche on Eau had nearly covered the whole globe; there was only a thin red arc of illumination at the top.

"The sunset's almost gone," complained Gretchen.

"Good," said Red. "Now we'll be able to see the stars and Sol once more."

"Feeling homesick, Red?" said Thomas. His arms were around the two women and he gave Red a squeeze.

Red nestled her head on the young man's shoulder.

"Not really," she said. "Earth doesn't have that many good memories for me—a struggle for existence that so dominated me that I spent all my waking hours in a blind quest for money. I was never happy, even though eventually I became a billionaire."

"Don't you ever regret giving up all that money and becoming a space-nun, sworn to a vow of poverty?" said Richard. He was sitting on the floor with the back of his head resting on the lounge seat.

"Never," said Red. "For the first time in my life I'm having fun." She squirmed against Thomas and tousled Richard's hair.

"Funny kind of fun," said Richard. "A nerve-wracking job landing a eighty-ton spacecraft on a wildly spinning double-planet, then tomorrow the real work starts when Gretchen forms her slave-gang to put the wings on the *Magic Dragonfly*. It all sounds like work to me."

"Sure it's work," said Red down at the tousled head. "But it's fun kind of

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work. I'd do it even if I weren't getting paid."

"Which we aren't," reminded Gretchen.

"See!" said Red. She turned to Thomas, whose dark face was almost invisible in the fading light.

"Where would Orion be now?" she asked.

"I'm not positive about anything any more since I landed on this whirlygig, but I think it's on the opposite side of the sky from Barnard and should be rising over Eau shortly."

"I see four bright stars in a line just above Eau," said Richard from the floor.

"That is Orion," whispered Jack through Richard's imp. "The yellow star at the right end is Sol." The ship was so quiet they could all hear the whisper.

The red rim about Eau faded away and the stars bloomed in the sky. Jack turned off the lights, and through the thin air they could see the black velvet of the sky sprinkled with multi-colored tiny gems.

Spread out below them was the wingless *Magic Dragonfly*. Beams of light streamed out the cockpit windows and the bulbous eye-like scanner domes to spread patches of light on the dusty surface. The air was still and cold as the icy stars sucked warmth from the ground. One by one the lights on *Dragonfly* flickered off as David and Arielle closed down their checkout activities.

There was a weak red glow on the distant horizon. It grew brighter.

"What's that?" came David's voice, transmitted through their imps from the *Magic Dragonfly*.

"It's probably an eruption from one of the volcanos on the inner pole mountain of Roche," said Red. She jumped up, clambered through the passway ladder to the upper control deck, and looked out the port up there.

"It's a real Fourth-of-July spectacular," said Red through her imp. She quickly turned and activated the science console.

"Can you get it on doppler radar, Jack?" she asked.

Jack's reply was a display on her screen. Soon Red's trained fingers were sliding over the surface of the screen from the command choice listings on the side to various portions of the false-color doppler radar image. The geologist in Red took over and she worked steadily until dawn.

Down below, the others enjoyed the fireworks display seemingly put on by Roche to celebrate their arrival. Orion with the four stars in his belt rose up overhead and disappeared from view. A number of minutes later a dull rumbling came through the air.

"It's the noise from the volcano," said Thomas, impressed. "Shucks, I forgot to count."

After an hour and a half came a false dawn, as Barnard came out from behind Roche and started to illuminate the other sides of the two lobes. They were still in the shadow of Roche, so they didn't see the sun, but there was enough scattering from the atmosphere between the two lobes that faint cloud patterns could be seen on the Barnard side of the water globe just above the black horizon of Roche that arched up to block the lower portion of the lobe. The false dawn set, and total darkness returned as Barnard

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continued its rotation and Roche fell into the shadow of Eau. The viewport lounge was quiet as Gretchen lay back, staring out at the limitless stars. When she heard deep breathing from the two men beside her, she allowed herself the luxury of a few quiet tears of homesickness.

The dawn was breaking over the distant arc of Eau when Gretchen assembled her press-gang. Everyone became common laborers as they helped Gretchen and the Christmas Branch assemble the outer wing panels of the *Magic Dragonfly*.

The panels were hollow graphite-fiber composite structures designed without internal bracing so that the wing panels nested inside each other. The nested wing sections fit neatly inside the lower portion of the lander on either side of the rudder of the *Dragonfly*. Using the upper winch, Gretchen and Jack carefully pulled each segment out one at a time and lowered them to a waiting team of spacesuited humans.

"Stand back," warned Gretchen from her vantage point up in the wing storage hold. "Let Jack winch the panel all the way down to the surface before you get near. I have epoxy that will fix the dings in the wing section, but I left my people-epoxy back home."

As each section was lowered slowly to the ground, the crew of eight would lift the five-by-six meter section of wing and take it over to place it on the ground on either side of the stub-winged *Magic Dragonfly*. After the wing panels were unloaded and arranged, Gretchen and Jack lowered a bundle of small struts and three long telescoping poles. Before she came down, Gretchen unfastened the lower winch and brought it with her to the plane.

"Okay, Jack," she puffed, as she clambered up to the top of the aerospace plane with the heavy winch and attached it to a waiting fixture. "Have the branch install the struts in the first section."

She motioned to the suited figures scattered about her below on the ground.

"This will be just like we practiced it on Titan," she said. She tossed down the end of the cable from the winch. "Set up the tripod over the section the branch is working on, then when the branch has installed the inner braces, hook the cable to the central lifting lug and get out of the way." Gretchen looked up at the sky. They had been working hard since daybreak and Barnard was already overhead. They were behind schedule. Slightly exasperated, she allowed a note of irritation to creep into her voice.

"And hurry up! We've only got an hour and a half of daylight left."

George picked up his pace as he went with Richard to pick up the tripod poles.

"Give a person a little authority and they turn into a Captain Queeg," griped Richard. Jack was a little slow on interpreting the proper routing of the message from Richard's suit imp, and it was only when Richard had gotten to the word "authority" that Jack realized that the comment was for George's ears only and not the general channel. A chorus of chuckles and giggles rippled through the net.

"I heard that, Richard," said Gretchen. "If you'd like to come up here and play steeplejack I'll be glad to trade places with you."

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"No thanks," said Richard. "Steeplejacking is squaw work."

The tripod was assembled and the first section was raised into place, the Christmas Branch riding up on the inside.

"We're about ten centimeters off, Jack," said Gretchen. The branch extended its body between the hanging section and the wing stub, then contracted to draw the two sections closer together. Gretchen straddled the narrowing gap and, using a long pointed pry-bar between two aligning lugs, she pulled the wing section forward until the edges were lined up.

"Hold it!" said Jack as the edges were about to meet. A large spider-imp scurried around the narrow gap, removing the thin plastic protective cover from the sealing material. Gretchen could feel internal fasteners clicking into place beneath her feet, then the pressure on her pry-bar lessened as the fasteners were rotated to pull the two wing sections together. Gretchen glanced below her chin at the array of tell-tales in the neck of her suit.

"That took us fifteen minutes," she said. "We'll have to do better than that on the rest of the sections if we're going to finish before sunset."

Richard glanced again at George. He didn't use his imp this time, but instead made motions with his hands as if he were playing nervously with some large steel marbles.

The outer wing sections, being much lighter, were on well before dark, and Jill was able to pump them down, check for leaks, then refill them with fuel from the main tanks of the lander while the tired construction crew reboarded the lander for a last dinner together. Tomorrow they would break up into two teams. Sam, Red, and Thomas would stay with the lander. Thomas would be Commander of Rocheworld Base, while Sam and Red went off on exploration jaunts in the crawler. The other five would take off on the *Magic Dragonfly* to visit the other side of Roche and the distant globe of Eau hanging in the sky on the eastern horizon.

"I won't say that I'm sorry to see you go," said Sam. He popped the last of the cherry tomatoes from *Prometheus*'s hydroponic gardens into his mouth. The tomato was good, but getting a little wrinkled from sitting in Jack's refrigerator this long. It was the last of the fresh food. It was basic mush and frozen foods from now on. "After I get your sleeping racks stored away I'll be able to stretch out at night."

"Enjoy it while you can, Sam," said George. "We'll be back in a few weeks. It's only 22 days or 88 rotations until Rocheworld reaches periapsis about Barnard. The weather on Eau is likely to get a little rough with the extra heating and I want to have the *Dragonfly* tied down here for those few days."

The next morning the exploration crew suited up early and gathered outside the lock of the aerospace plane. Gretchen and the Christmas Branch had already uncapped the electrically powered VTOL lift fans in the wing roots, and they were ready to go.

"Now we'll see what this magic carpet can do," said George.

"*Magic Dragonfly*," reminded Arielle. "It can do everythings."

"Take me to a strange land, where I've never been before," said George.

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"All right," said Arielle. "Hop on board."

Pilot and co-pilot-commander waited as David, Richard, and Gretchen passed through the airlock of the *Magic Dragonfly*, then the two figures grinned at each other as they followed them inside. The slimmer figure hesitated and let the larger one enter the lock first. During the wait, tiny fingers hidden in sausage-finger gloves stroked softly over the duraluminum hull. Then, the "magic" for the *Magic Dragonfly* stepped aboard.

FLYING

Arielle made her way forward toward the flight deck through the busy humanity inside the plane. She had some trouble getting past the science console area, since David and Richard were busy setting up the next day's schedule. She slid her thin body past this blockade only to confront a long torso stretched horizontally across the aisle from the port science blister to the starboard science blister. The head of the muscular body was buried deep in the port science electronics, and the rest of the body seemed to be ignoring the 10% gravity of the planet below. It was either crawl over or crawl under. Arielle took a calculated look at the broad buttocks and muscular waist, then launched herself in a soaring low-gee dive over the human tollgate. She did a mid-air flip and straightened out so she was flying through the air feet first. George looked around just as the human bird fluttered to a landing on the raised platform between their seats on the flight deck.

"We are ready?" she asked, buckling herself into the pilot seat.

"Lift-off!" said George.

Arielle glanced at the console and took over the controls. She smoothly increased reactor power and adjusted fan pitch and speed at the same time. The *Magic Dragonfly* slowly floated upward into the ammonia skies.

Once they had reached adequate elevation, Arielle pushed the VTOL controls forward. They responded by tilting the huge electric fans in the wing of the plane until they were pushing the craft forward as hard as they were lifting it. Automatic servomechanisms took over, and the power of the nuclear reactor was increased to provide more heating to the streams of thin atmosphere that were captured by scoops in the side of the plane.

Arielle added a notch to the throttles, and the heat exchangers between the nuclear reactor and the frigid, −40 C air turned cherry red. The heated methane, ammonia, and water vapor began to stream out the rear jet at high velocity, impelling the *Magic Dragonfly* forward.

Richard was sitting at the science console, orchestrating the first portion of their mission.

"I'd like some altitude first, please, Arielle," he said. "And David, if you and Jill can look through the memory for ground scans taken during the descent of *Eagle*, I'd like one with a shadow angle similar to what we have now."

The aerospace plane banked as Arielle moved the *Magic Dragonfly* into a lazy spiraling climb above Rocheworld Base.

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"Scanners are all active," said Gretchen from the engineering console.

"I'd like the radar sounder image," said Richard. His hands flew over the screen as he shrunk the radar image into half the screen, then placed the old image from the *Eagle* in the other half-screen. It was the same region, but they were taken at different angles and distances.

"Rotate and rectify, Jill." The old image distorted as Jill rearranged the bits in the image. Richard's hands played over the command list and the old image faded into a deep red, while in the center a small white circle indicated the smaller region that was now being scanned by the radar sounder on their magic carpet.

"There's an interesting feature to the north, Arielle." He placed his finger on the fuzzy red blob.

Arielle glanced at the small video to one side of her main display. It was a reproduction of Richard's science screen with a blinking green fingerprint-sized blob overlaid on a red blob. Arielle continued a half-turn, then straightened out the *Dragonfly* on a northerly climbing course. Soon the region of high-resolution radar sounding data grew in size and moved northward until the red blob was revealed as a small crater that appeared to be perched on a teardrop-shaped mesa, the blunt end of the teardrop facing due west.

"Looks like a Martian crater," said George. "I can see it coming up ahead. There are flow lines that look like the crater was made in the bed of a stream and the stream flowed around it for some time before it dried up."

"It's only 100 kilometers from Rocheworld Base," said Richard. "I think I'll put that on the visit agenda for Sam and Red."

"I don't think they're going to like you for that," said David. "They'll only be able to travel in daylight. It'll probably mean 15 hours in suits just for three hours of daylight on site."

"They're dedicated rock-hounds," said Richard. "Besides, the crawler will do most of the work."

Arielle took the *Dragonfly* in a slow circle about Rocheworld Base while Richard picked out a few more targets for the base-sticking crew to visit. Arielle then applied more power and started a spiraling survey of the entire globe.

"Lots of craters on this side," said Richard, to no one in particular.

"Like the moon, but with air," said George, scanning the horizon out the cockpit window. "I don't see any more signs of erosion."

"We would expect most of the precipitation to take place in the cold crescent that runs from the north pole to the south pole through the inner pole," said Richard. "Those portions receive proportionately less sunlight than the warm crescent that stretches out along the equator from the outer pole."

"I see some white stuff on the ground up ahead," said George. "Especially on the north side of crater rims."

"We getting close to north pole," said Arielle. "She is probably snow."

"Probably a mixture of ammonia and water ice," said Richard. "The temperature there is probably −100 C."

"And I thought it was cold at Rocheworld Base," said Gretchen.

"We'll soon find out," said Richard.

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He put his finger on his screen. "Arielle, could you bring us down here in the middle of this large crater? I want to get some snow for Gretchen to look at and some bedrock chunks for my collection."

"We descend!" said Arielle, putting the *Magic Dragonfly* into a dive. Darkness came again as they approached the site. Using radar, Arielle and Jill carefully landed on a flat place not too far from the central peak of the crater, the ammonia snow blowing out from beneath the VTOL fans into the bright beams of the landing lights.

"Three winks, everybody," commanded George. Gretchen and David had anticipated George and were already in their bunks. It didn't take long for the rest to join them. Daybreak and a full schedule were only three hours' nap away.

The next day, all three hours of it, was spent collecting specimens of rock, soil, and snow. Gretchen and Richard came through the lock as Barnard set.

"Where to now?" said Arielle.

"Head for the inner pole," said Richard, "but take us over the big lava volcano. I want to get some infrared pictures."

Arielle headed the *Magic Dragonfly* toward the inner pole in the deep Roche darkness. They hadn't far to go, and the gravity dropped even more. Using Jill's radar, they found a flat place and landed to wait for daylight.

Gretchen came up from the back, bouncing as she came.

"This is ridiculous," she said. "All that dirt out there and it isn't keeping me on the floor."

"You keep forgetting that equally large ball of dirt overhead," said David. "Why don't you put on free-fall boots? The floor has loop carpeting."

"They're back at Rocheworld Base," said Gretchen embarrassedly. "I was so busy checking everyone else's kits that I didn't check mine. Besides, I didn't expect to run into free-fall in an airplane!"

"This is magic airplane!" said Arielle. "It can even abolish gravity. It almost sunrise, we shall go?"

"Yes," said George. "Up please —and don't stop until up is down."

Arielle started the lift fans at low speed and the *Magic Dragonfly* rocked and lifted rapidly in the half-percent gravity at the inner pole. She switched to the nuclear jet and started a tight spiral climb.

"Ten kilometers and climbing," she announced, as the ball of Barnard rose behind Roche while Gargantua appeared from behind Eau. The sunlight from Barnard illuminated the water mountain above them while the ground below was still in darkness.

"Twenty kilometers and climbing," said Arielle. "Gravity now less than 1/300ths gee." Things started to float around in the cabin in the currents from the air conditioning system. The room was soon full of busy mosquito-imps cleaning up the air.

"No ring waves," said George, looking up. "The wind is going downmountain." Barnard now illuminated one-half of the conical ocean with its red glare, while the other half was more softly illuminated with the reflected light from Gargantua.

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The drone of the lift fan engines slowed.

"Forty kilometers altitude and stopped," said Arielle. "We at mid-point."

Gretchen took a pen from her coverall pocket and suspended it in mid-air. It drifted slightly in the air currents but fell neither toward or away from the Roche lobe below.

"Zero-gee," she announced.

"With the sun now shining on Eau, the ammonia will start to boil out of the ocean and the wind will start blowing the other way," said George. "If we are going to get any samples or make any measurements we'd better do it soon."

"We go down?" said Arielle, starting the lift-fans. The aerospace plane gathered speed and within a few minutes was hovering over the surface of the rounded tip of ocean at the inner point of Eau. The gravity had risen to a half-percent of gee and things once more took on their normal orientation, except overhead was now a conical mountain of rock instead of a conical mountain of water.

"Three meter above surface," said Arielle. "The wind are drooping down."

"Lower the sonar scanner, Jill," commanded Gretchen. There was a bumping noise from beneath the ship as the small package of sophisticated sound-generating and -detecting equipment dropped out of a hatchway on the bottom of the plane and splashed into the water.

There was a blip on the screen as Jill fired the first strong burst of sound down into the depths, then a pause as the trace made its way slowly across Gretchen's screen. As the green line approached the right side of the screen, there came a blink, and the scale increased ten times. The blip, now moving only one-tenth as fast, continued across the screen, passing one depth marker after another.

"It's really deep," said Gretchen. "The marker is at 50 kilometers and still going."

"That's five times deeper than the deepest ocean on Earth," said George. "I wonder what the pressures are like down there."

"Shouldn't be too bad," said David. "Don't forget the reduced gravity."

"I think the signal must have been attenuated by a muddy bottom or something," said Jill through Gretchen's imp. "I'll try a longer burst with a chirped frequency and then compress the returns."

"Fine," said Gretchen, then watched as a ten-second-long, slowly rising whistle of sound wended its way into the depths.

"There it is!" cried Gretchen, as a return showed up on her screen.

"That is a return from the first signal," said Jill. "I will reconfigure the screen." Instantly the engineering screen was rewritten with a time display that contained a new length scale, while below it was a two-dimensional picture of the bottom surface that grew second by second as the acoustic pulse made the round trip to the bottom at 1,500 meters per second.

"The bottom is 150 kilometers down!" said Gretchen. "We're on the top of a mountain of water 150 kilometers high!"

". . . and it doesn't fall down," added David.

Gretchen watched the screen as the

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second and third pulses returned with their information and the details on the map cleared up. Richard looked over at her screen and pulled a copy of the map onto his screen.

"Those circular features are obviously volcanic craters," he said.

"What are those jagged features?" asked Gretchen. "They look like underwater Alps."

"Perhaps that's what they are," said Richard. "There are certainly enough tidal stresses to cause mountain-building."

"There was nothing like that on Roche," said David. "Lots of volcanic craters to match the ones you see there, but nothing like those mountains." David pulled a copy of the display onto his screen and peered closely at it.

"They seem to avoid the craters," he said. "How tall do you estimate them to be?"

"About two kilometers," said Richard. "Not really big for mountains considering the gravity. If they are mountains . . ." he added.

"Pull the sonar in, Jill," said Gretchen. "Don't forget to get a sample. I want to analyze the water."

"My scanner has a built-in analyzer," said Jill. "The ocean at this point is −23 C and warming, with a composition of 39 percent ammonia and 55 percent water, with trace amounts of methane, hydrogen sulfide, and hydrogen cyanide dissolved in it."

"Any trace of anything unusual?" asked Gretchen eagerly. "It would sure be wonderful to find a life-form. Even the tiniest microbe would pay Earth back for what it cost to send us here. The discovery of a different form of life would have a profound influence on our understanding of biology and medicine."

"Nothing," said Jill.

George had been looking out the cockpit window at the horizon. "The waves are rising," he said. "If we are going to get any more samples and bottom maps, we'd better be moving."

"We go up!" said Arielle, and the *Magic Dragonfly* leapt into the air and moved along the flank of the mountain of water, trying to stay as long as possible in the rapidly diminishing patch of sunlight.

"Can't you bring her down a little lower?" asked Gretchen. "The sonar is breaching the surface in some of the troughs."

"You argue with Jill," said Arielle with a fatalistic shrug of her shoulders. "I could go lower, but she is not allowing me to try."

"Jill!" said Gretchen. "We're at 100 meters and the waves are only 30 meters high. Surely we could go down another 10 or 20 meters."

"No."

Arielle, who had never stopped her automatic scan of cockpit window and instrument panel, suddenly reached for the controls and thundered *Dragonfly* upward on its rocket thrusters.

"Arielle!" yelled George. "Rockets!?!"

In reply Arielle swiveled the plane on its lift fans in time for George to see a large, tsunami-type high-speed wave heading off up the mountain.

"Its direction of travel is different than the wind waves," he said. "That must have been caused by an underwater disturbance."

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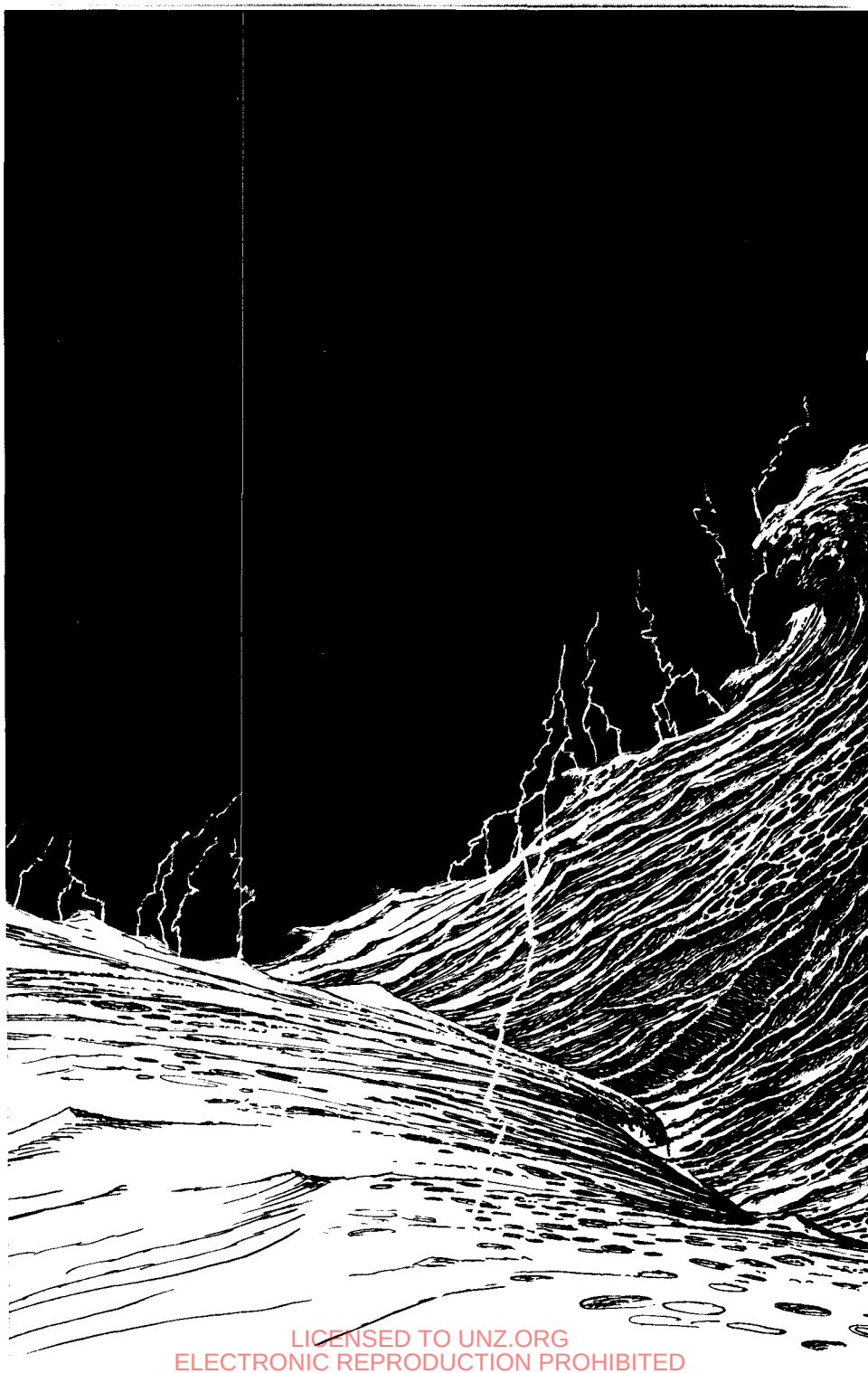

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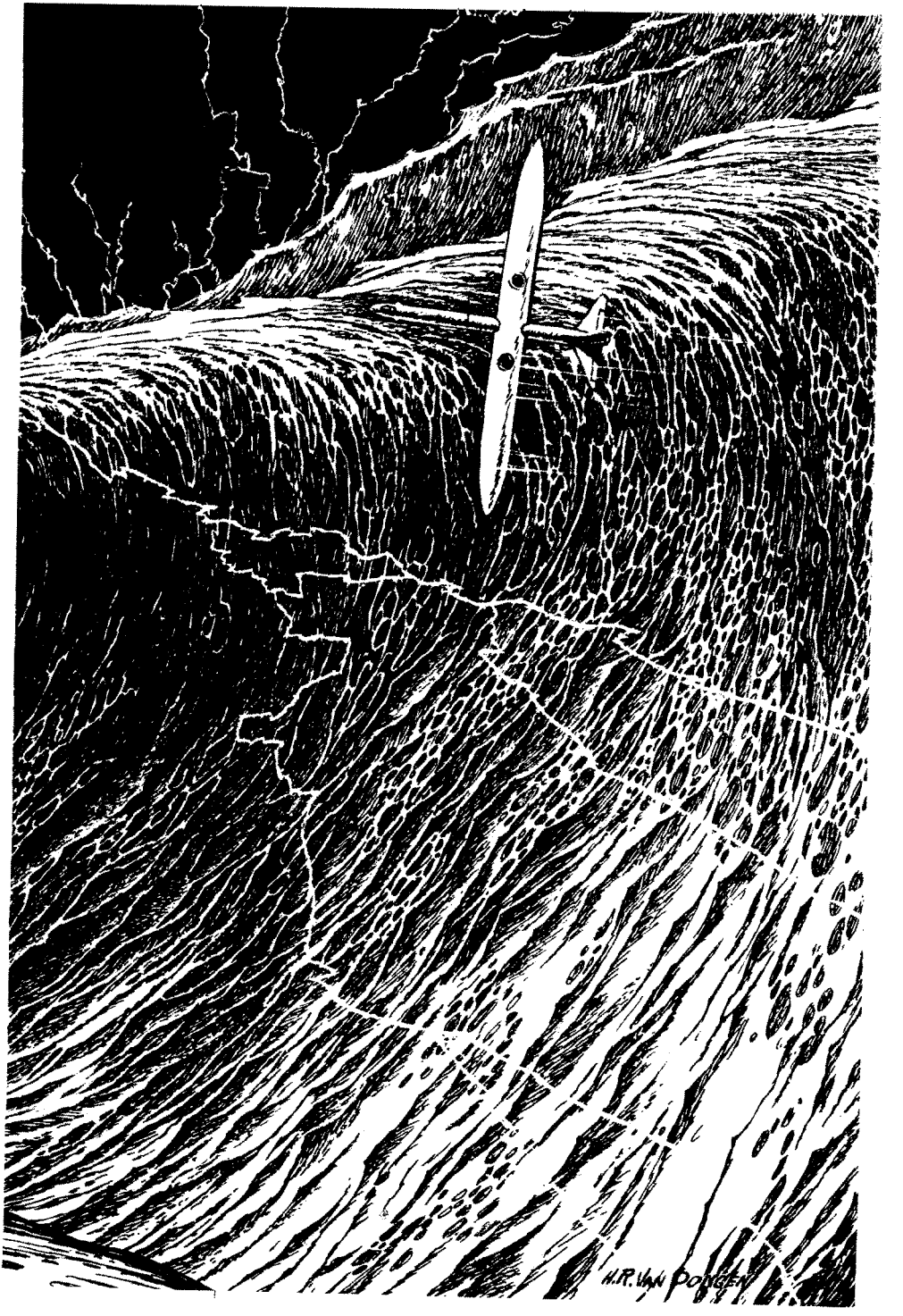

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"There was a big underwater noise not too long ago," said Gretchen. "Must have excited that tsunami. I wonder how tall it was."

"Eighty meters," said Jill.

"Then Arielle didn't really have to use rockets."

"If *Dragonfly* had been where you wanted it," said Jill, "that would have been the only thing that would have saved us." The tone of the computer voice was unusually severe.

"Hoist on your own petard!" laughed David.

"What are you talking about, David?" asked George.

"I'll let Gretchen tell you," he said, getting up and making his way back to the galley.

"Gretchen?"

For a while Gretchen didn't answer. Then she said, "David and I developed the various voice programs for all the computers on the mission. *I* programmed the severe 'I told you so' tone that you just heard."

"You did a good job," said George. "After hearing that voice, I certainly wouldn't argue with Jill over a safety matter. Wouldn't want to get on her bad side."

Barnard set behind Eau. They watched it go, then Arielle took the *Magic Dragonfly* around to the other side to await sunrise two hours later. They hovered at altitude, resting and napping until the sun rose again from behind Eau.

"Wow! Look at those waves!" said George.

"Surfer's paradise?" asked Gretchen.

"Purgatory," said David. "Those waves are so big there's no way you could ride them, even if you didn't need a suit to survive."

"It would still be fun to try," said George. "I learned to handle the big killer waves at Diamond Head, so I ought to be able to take on these, especially in the reduced gravity. Just think: a 300-kilometer ride on a 30-meter wave."

"Until you reached the top," reminded David.

"Yes . . . the top . . ." said George, looking out the window at the sunlit side of the mountain of water. Heated by Barnard, the ammonia-water ocean had gotten warmer and the ammonia had boiled off into the atmosphere, raising the pressure on Eau and causing a stream of wind to flow up the mountain to funnel through the narrow gravitational neck onto Roche.

"That was a BIG one," said George, admiring the fountain of water that appeared at the top of Eau mountain. In the light gravity, the spume of water from the implosion of the kilometer-high ring wave shot 20 kilometers into the air, where the spray was tossed up still farther by the rush of air from Eau to Roche. Lightning flashed, and clouds formed in the turbulent saturated air. David came forward to look out the cockpit window.

"Look," said David, pointing at the clouds above and below. "The clouds are swirling one way north of the peak and the other way in the south."

"It's the coriolis force," said George. "Whenever you have mass flow in a rotating system, the coriolis force makes the flows move in circles. We have the same thing on Earth. Counter-clockwise hurricanes in the northern hemisphere

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and clockwise ones in the southern hemisphere. It's significantly different there, though. On Earth, the maximum coriolis force is at the north and south poles, but there are no strong air currents, so the maximum storm action is in the mid-latitudes. Here the air currents are at maximum right at the center of rotation, so we get strong storms."

"They look like giant tornados.." said Gretchen. "One stretching north and one going south."

"They are," said Arielle. "But they are lazy ones because of low gravities. Not to be afraid."

The exploration survey turned routine. They would fly a hundred kilometers, hover to dip down the underwater sensor package, measure the distance to the bottom, analyze the water content, then take off again for the next survey point.

"I'm beginning to see a definite pattern in the water composition," said Gretchen. "It matches the weather and temperature patterns."

"The usual yin-yang pattern?" asked David.

"More like the two halves of the cover on a baseball," said Gretchen. "Barnard heats up the equatorial and outer pole region to about zero degrees centigrade, and the ammonia boils out of the ocean, leaving it water-rich and heavy. The high-pressure atmosphere then travels to the cold region and the ammonia rains down on the spin poles and the inner pole, making the ocean there ammonia-rich and light."

"That would explain the ocean current patterns I'm getting from the doppler-radar mapper," said David. "There is a general motion from the cold arc to the warm arc. That would be the lighter ammonia-rich liquid returning over the surface, while the heavier water-rich liquid closes the circuit along the bottom. Makes for a topsy-turvy ocean, hotter at the bottom than on the top."

"I wouldn't call zero C hot," remarked Gretchen. She started the winch that would retrieve the ocean-sensor package from beneath the waves and nodded in turn to Arielle, who smoothly lifted the *Magic Dragonfly* up into the air on its VTOL fans and transitioned into level flight. The nuclear jet kicked in and the *Magic Dragonfly* screamed through the thin air toward the next survey point.

Warm@Amber@Resonance lay spread out on the surface basking in the red rays of Hot, the heating light. Hot was getting bigger and the heat that it emitted was increasing, while Warm was shrinking again and would soon fade away, not to return for 480 days. The huge body relaxed even more and spread into a thin layer in the shape of a rough circle 100 meters in diameter, a large amber blotch that rode the waves as they rippled underneath the jelly-like flesh.

Then, weakly, there came a noise. The acoustic senses in the amber creature went on alert. It sounded like a whistle from an underwater volcanic vent, but it had no direction. It seemed to come from every direction at once! The noise grew louder as if some invisible monster were emitting a hunger cry.

Warm@Amber@Resonance searched the water beneath with burst after burst

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of sound pulses from its body, but it could see nothing. Then, just after the shriek from everywhere had reached its peak, the red glow from Hot flickered into blackness for an instant. Frightened, the vulnerable sheet of amber rapidly contracted into a three-meter ball, its sonar still searching for the source of the danger. It sank to the bottom as the ocean liquids were squeezed from the jelly-like flesh to turn it into a tough plastic-like rock.

"Anomaly found!" said Jill to Gretchen and Arielle. A picture appeared on their screens. Jill had outlined the anomaly with a blinking green circle, but the cue was unneeded. In the center of the screen was a ragged circle of amber "ocean."

"It also appears in the infrared scanner," said Jill. The same scene in the false colors of the infrared display flashed on in place of the video scene. The blotch was still amber in this scene, indicating it was significantly hotter than the water.

"Must be a plume of ejecta from an underwater volcano," said Gretchen. Richard looked up from his seat in the galley, put down his bowl of vegetable soup, and came forward, bounding in the low gravity in his eagerness.

"I'd like to see that!" he said, stopping himself by grabbing on Gretchen's shoulders. "Can Jill find the spot again?"

"We on our way around," said Arielle, putting the *Magic Dragonfly* into a wide turn. "Should be easy to see something that big."

"Are you sure this is the spot?" asked Richard, as they hovered 100 meters above the surface of the ocean.

"I have Clete in sight, so my navigation accuracy is better than one meter," replied Jill.

"Go up," said Richard. "Perhaps it floated off from where we saw it." Arielle took the plane rapidly to altitude. They went up a kilometer, the scanners in the eyes of the *Magic Dragonfly* vigilantly searching the rapidly increasing circle of ocean.

"The currents aren't more than a few kilometers an hour in this region and it only took us twenty minutes to return. We would have seen it if it had just drifted off," said David, monitoring the IR scanner while Gretchen and Richard looked at the visible display.

"Let's go back down and take a look underneath the surface," said Richard. "Even if the cloud has dissipated, the underwater volcano should still be there."

Arielle pushed the down button and the magic elevator dropped smoothly to a position 10 meters above the top of the waves. Gretchen lowered the under-ocean sensor package on the cable, and it splashed into the water. Through the noise of the splashing the sonar sensor on the package heard some high-pitched squeaks, then echoes of those squeaks from distant rocks and underwater hills. They were too few to obtain an accurate direction fix, but they seemed to come from nearly directly below.

Jill hesitated before starting the sonar sender, waiting to see if the strange squeaks would reoccur, but the volcanic vent had fallen dormant. Jill started the sonar pinging, and soon a picture of the bottom built up on Richard's screen.

"There's nothing but mud and a few

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rocks here," he complained. "I don't see any sign of a vent."

"The water composition is just what it should be," said Gretchen. "If there were significant volcanic activity you'd expect an excess of impurities like hydrogen sulfide."

"Then the blotch wasn't volcanic," said Richard. "But what caused it? And where did it go?"

"Barnard will set in 25 minutes, and we are behind schedule," reminded Jill.

"Okay," said Richard. "Why don't we continue the survey, and I'll finish my soup. But would you rerun the data on the video in the galley? Maybe I can puzzle it out during dinner."

Warm@Amber@Resonance stayed quietly on the bottom for a long time with its senses alert, but it could see nothing. The strange noise returned, then the screaming changed to a throbbing. The throbbing grew loud, then faded away, only to return once again. Suddenly something big and hard appeared with a splash at the top of the ocean. The amber rock fell silent while it carefully analyzed the last few sound pulses it had bounced off the strange monster. It was not too big, but it was as hard as a rock. None of the pulses traveled to the inside of the monster. If it was that hard, how did it float? The creature was quiet for a while. Then it gave off a blinding burst of sound that repeatedly flooded the bottom with illumination. Warm@Amber@Resonance stayed motionless and waited while the sound that reflected from the bottom reached the top again, self-illuminating the hard visitor from the sky. Tiny doors opened in the monster and sucked in water. Strange, stiff appendages with inset circles pointed this way and that, while burst after burst of sound throbbed from the underbelly of the creature. Then, as suddenly as it began, the being stopped its seeing, and without seeming to move anything, swam upward and out into the nothing above the ocean. The throbbing noise increased, then faded off, to be replaced by the hideous shriek, that thankfully also faded off. The dread creature was gone. It was near the time for Hot to travel to the other side of the world. The amber rock dissolved into a floating blob of jelly and swam rapidly away.

Warm@Amber@Resonance had lived 374 seasons and was a leader of the pod. This hard screaming monster was something unknown, and that was nearly impossible in a world where no one ever forgot. There were others that were much older, such as Sour/Sapphire/Coo. Perhaps the elder would know about the strange monster.

Warm@Amber@Resonance was not exactly sure where the elder was, but since the research problem the elder was working on was a difficult one, it would take many returns of Warm before any solution would be found. For that length of concentrated thinking time, Sour/Sapphire/Coo would have to rock up under a protective shell. The shell required periodic exposure to air to maintain itself, and that meant going to one of the Islands of Thought.

Warm@Amber@Resonance traveled at top speed, but it was still two days before it reached the chain of islands on the warm pole.

"I give up," said Richard many

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hours later. "I don't see anything more in those pictures than we did before. The amber blob is definitely there, not drifting much as we pass over it; then as we go over the horizon it looks like it starts to shrink, but the foreshortened perspective makes it difficult to be sure of that. Then when we return twenty minutes later, it's gone!"

"I'll keep working at the analysis," said David. "You'd better get your programmed sleep. You don't want to miss your island vacation trip, do you?"

"Are the Hawaiian Islands coming up?"

"They're only nine hours away on the science schedule," said David. "And I know you want to get out and swing your pick at some of the outcroppings."

"Right! Wake me up as we get near. My pick is getting rusty on this waterball." He headed for the bunks in the rear, grabbing a proto-protein cookie for a belated dessert as he passed the galley.

The "Hawaiian Islands" were six oval-shaped rings of low mountains spread out in a line that crossed over the outer pole of Eau. The ocean was shallowest in this region, only a few hundred meters deep, allowing modest mountains to stick their peaks above the surface. Each island had been named after one of the Hawaiian Islands: Hawaii, Maui, Lanai, Molokai, Oahu, and Kauai. Richard was awake and suiting up as George flew a high-altitude survey pass over the chain as dawn broke over the horizon. Gretchen made her way back through the crew quarters to check Richard out just in time to see Arielle climbing into her upper bunk dressed in her bunny pajamas.

"Aren't you going to stay up and see the islands?" asked Gretchen, a little surprised.

"Piloting is hard work," said Arielle. "I would have fun to see them, but I now get my beauty sleep." She closed the Sound-Bar door as Gretchen continued on her way.

"So that's her secret," mused Gretchen to herself. "Must try it myself some day." She closed the privacy curtain behind her and, striding up to the suited figure standing in front of the airlock, she unceremoniously began punching the buttons on the chest console and reading the responses. Richard rocked slightly with each punch. Used to this kind of treatment, he ignored Gretchen and talked through his suit imp to George.

"Fly back over from the sunlit side and let me watch on my holovisor," he said, reaching up a gloved hand to pull a dark-grey lid down over his visor. The inside of the visor lit up with tiny laser diodes into a hazy image, mostly blue with some reddish splotches. Richard forced his eyes to relax and, as they stopped trying to focus on the nearby points of light from the diodes, the holographic multi-color laser pattern reformed itself into an image of a rectangular video display at normal console distance. The array of tiny lasers generated at the surface of the visor the same light patterns, complete down to the phase, that would have crossed the surface of the visor from the video display if it had really been there.

"With their ring shape, they look more like atoll islands than the volcanic Hawaiian Islands," said George.

"They were only blobs on the fly-by

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probe pictures," said Richard. "But they're not atolls, either. Those are formed by coral. Although I'd love to find even some low form of life like coral, I don't expect it here."

"What caused those rings, then?" said George. "Volcanos? And in that case, how come they're oval?"

"My guess is that they're impact craters from a large meteorite," said Richard. "The meteorite broke apart in the upper atmosphere and came in at a low angle. Notice that the ovals are all lined up lengthwise with the general trend of the chain."

"I see what you mean. I'm going down. Any particular one?"

"Find a flat spot on the inner side of Hawaii; I'm more likely to find some folded-back inner crust there."

"Which one is Hawaii?"

"The big one at this end. They're named in the same order as the Hawaiian Islands back home."

George was silent as distant memories of indolent days at Diamond Head flooded through his mind. He blinked back a tear of homesickness and started the long descent.

"Richard," called David over the suit imp. "I've been going over the pictures that the scanners took on the way in. Pull down your holovisor. I want to show you something."

Richard and Gretchen, now suited as well, reached up to pull down their holographic viewing screens. Hidden behind grey visors, they watched as David zoomed the view down into the center pond. The oval mountain chain was about five kilometers wide by ten kilometers long, but it was not continuous. There were a number of places where the ocean had broken through to the interior of the impact crater. Not far from one of those entrances was a small blob of amber and an even smaller blob of blue.

"Jill would swear from the spectrum that the amber blob is the same type of stuff as the large amber blotch that disappeared. She's not sure, though, since this blob is under a meter of water."

"What does the infrared sensor say? Never mind . . . the water would kill that."

"There is a slight increase in the surface water temperature," said David. "But that could be explained just in terms of the difference in reflectance of the blob underneath."

"Land us there," said Richard. "I'm going over for a look."

Warm@Amber@Resonance searched from one island to another. A sour scent led it to the elder, a large blue rock lying just below the surface of the ocean. The amber cloud surrounded the blue rock and shouted.

@Open up! There's a hard screaming monster in the ocean! What is it!?!@

There was no immediate reply, but Warm@Amber@Resonance didn't expect one. Sour/Sapphire/Coo had taken for its research project the derivation of an example of the fifth cardinal infinity. It had been twelve seasons of the visitations of Warm since the massive blue elder had left the pod and traveled to the Islands of Thought. Warm@Amber@Resonance had hesitated to distract the elder, but with an age exceeding 1,000 seasons surely the old one would know if such a strange monster had been

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seen before and whether it was dangerous. The wait was necessary to allow the thinker to complete its present train of thought and put all the portions of the unsolved problem in a state where they could be picked up again without error. Hot traveled around to the other side of the world, and the tides rose again. Finally a soft voice murmured from behind the protective shell.

/A hard screaming monster?/

@It is too hard to float, but it does. It swims without moving. It can even swim in the air!@

A crack opened in the shell.

/Let me taste./

Warm@Amber@Resonance formed a tiny tendril of an appendage and stuck it in the crack. Memory juices were exchanged.

/I never saw or learned of any such monster. It is your problem. I return to mine./ The crack closed and the blue elder returned to the problem of the fifth cardinal infinity.

Warm@Amber@Resonance was so busy absorbing the brief taste of the masterful strokes of the thought processes Sour/Sapphire/Coo used in its solution thus far that at first it didn't hear the high-pitched noise. The exchanged memory juices finally absorbed and incorporated into its own, the amber cloud suddenly reacted.

@The monster returns!!!@ Like a tuna sensing a shark, the amber blob formed into a slim swimming shape and sped off into the deep ocean.

Before landing, George hovered the *Magic Dragonfly* over the spot on the ocean where the scanner had seen the colored blobs.

"I see the blue thing. It's a big deep-blue-colored boulder, but the amber blob is gone," said Richard.

"Again?" said George.

"Yep. But that boulder isn't dissipating," said Richard. "Let me down on shore. I want to wade out and get a chunk."

"Richard!" said Gretchen, her cry echoing that of Jill through Richard's suit imp.

"When is low tide?" persisted Richard.

"In a half-hour," said Jill.

"And how much will the water level drop between now and then?"

"Over a meter."

"Which means I'll be able to walk right out to that rock and chop off a chunk and hardly get my feet wet."

"But your suit . . ." protested Gretchen, when Jill didn't respond.

"If my suit is good enough to keep out this poison we call an atmosphere, it's good enough for the cleaning solution that we call an ocean," said Richard. "And the extra amount of heating power I'll need for the short trip is nothing to worry about. Right, Jill?"

Gretchen and Jill reluctantly agreed to let Richard have his way. Gretchen insisted that she tie a safety rope to him before he started out, and he let her. His first steps into the retreating ocean were dramatic, as clouds of evaporating ammonia boiled off at each step, but soon the outside of his suit was as cold as the water and he plowed through the thigh-deep ripples to the deep blue boulder. Once there he looked it over carefully, then raised his pick and broke off a small piece. It was lighter blue inside. Richard put the prize into his collection bag and waded back to shore.

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"Hawaii has too many tourists this season," he said. "Let's take a hop over to Molokai." He and Gretchen got into the airlock, and George lifted for the short trip to the next island, 60 kilometers away.

"Any more islands?" asked George, after Richard and Gretchen had climbed back through the airlock.

"We've done Hawaii, Maui, Molokai, and Oahu," said Richard. "That should be enough for a nine-hour tour. Besides, it's almost sunset again. Let's head back to the inner pole."

"I recommend that course," said Jill. "It's only fifteen days to periapsis, or 60 day-night cycles. The weather at the inner poles is already getting stormier as it gets warmer. I would like us to be back at Rocheworld Base at least 10 days before periapsis."

"That gives us five days for survey stops. Is that going to be enough?" asked Richard.

"It should be," said Gretchen. "We have most of the place mapped, and the data matches the atmospheric and ocean models well. It's just a matter of getting enough samples to keep the statistical errors down. Except for those islands, this place is pretty dull. It would have been different if we'd found any evidence of life, but no such luck."

"Did you get an analysis done on that blue rock?" asked Richard.

"Yes," said Gretchen. "It was very similar to that silica-gel crystalline rock that Sam found over on Roche. It must take a strange chemistry for that to form. Neither Jill nor I have been able to come up with a good process yet."

Arielle walked forward and made her way to the cockpit. She was still slurping away at a vanilla algae shake. George got up, turned the plane over to her, and stiffly made his way back to the crew quarters and bed. Arielle glanced over the control panel, looked out the window at the setting sun, and, raising power, lifted the *Magic Dragonfly* into the crimson skies.

Two days later, it was George who first spotted Roche from his vantage point at the cockpit window.

"Land ahoy," he shouted throughout the ship as the edge of the twin world showed reddish-brown over the blue-grey waves. After another half-hour they were within line of sight of Rocheworld Base.

"Welcome back," said Thomas. "Red says from down below that she can see your contrail from the viewport window."

"Pretty good eyes," said George.

"Especially when in back of a 30-centimeter telescope," broke in Red's voice. "Even though we're nearly always in contact through one comsat or another, it's still nice to see you directly."

"We'll be home soon," said George. "A few more survey stops to fill in the gaps in the records, then across the neck in time for periapsis."

"Watch that weather," said Red. There's a nice storm brewing above the water mountain and it's coming your way."

"We'll fly over it," said George. "See you soon, beautiful." George got a weather map from Clete and talked it over with Jill.

"It's moving fast, but we should be able to take one more survey sample

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before dark, then get back to altitude before it arrives." As he spoke, George put the *Magic Dragonfly* into a steep dive and headed for the ocean surface. He brought the plane to a hovering stop in the strong surface winds, and Richard let down the ocean sampler into the rolling seas.

"That's some wind," remarked Richard as he monitored the drop through the bottom video camera. "The cable is trailing 30 meters downwind. Hold it for a minute until I get a return from the bottom . . . Got it! Take her up!"

George applied power, and the *Magic Dragonfly* climbed into the scruffy sky. The sun was setting, but George easily kept track of the clouds by the nearly constant lightning flashes. There was a crash from the galley as the plane dropped a few hundred meters in a vicious downdraft, then they were forced into their seats as an updraft sent them spiraling skyward again. George raced in front of the storm to stay in quieter air while he climbed. They were going around the mountain now, and Rocheworld base dropped below the horizon behind them. The air became smoother as the nuclear jet thundered them upward. Finally George put the plane into a turn and headed back up the mountain. Arielle had been sitting in the co-pilot seat. Her hands were in her lap and her eyes were busy scanning the instrument panel and the view outside. George looked over at her, put the plane on autopilot, and stepped down into the aisle. Arielle slipped quickly over to the pilot seat and strapped herself in. She left the plane on autopilot. Her hands went back into her lap and her eyes kept busy.

"We've passed over the front, and there's a clear region before the next front," said Richard from the science console. "One of our survey points is there. If you're willing to try a night landing we can get it out of the way and be that much closer to going back."

"Give me good weather maps, good radar, and good altimeter, and I don't need to see," said Arielle. "But just to be on safe side, I turn landing lights on near the waves."

Arielle took the controls and spiraled down into the inky blackness below. The distant orb of Gargantua was now too small to be of much use as a source of light, but she didn't need light, for the radar picture of the clouds and surface were all that she and Jill needed. As they came down below 500 meters' altitude, Arielle turned on the landing lights. Their position was on the high gravity equator, where the gravitational pull peaked at nearly 12% of Earth gravity. The waves were smaller but faster-moving, and looked somehow harder as they scudded along. Richard dropped the sampler in the ocean and waited for the sonar return from the bottom. It came almost instantly.

"The bottom is only 30 meters down," he said in amazement. "This must be some sort of an underwater plateau."

"The water composition is radically different, too," said Gretchen from the other console. "There are lots of dissolved gasses and strange chemical compounds. The temperature is also anomalously high."

"I think we must be near a volcanic vent field," said Richard, as he watched the sonar map build up to show a slope

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rolling off to one side. "Let's head upslope and drop the sampler in again."

"Okay," said Arielle. "Uphill is which way?"

"Toward Roche."

"Toward Roche we go," she said, lifting the plane and moving it a kilometer east, then lowering it again.

"The bottom is getting closer," said Richard.

"And the water is getting warmer," said Gretchen.

"Another kilometer Rocheward?" asked Arielle. Suddenly Jill interrupted.

"Arielle. Radar. 10 kilometers and moving toward us!"

Arielle glanced at the radar display to see a large, rapidly moving cloud breaking away from the more slowly moving front that was approaching. Beneath the cloud was a swarm of smaller swirling clouds. She pointed the video cameras in the *Magic Dragonfly*'s eyes in that direction and the sensitive cameras turned night into day on her screen. The scene was illuminated by near-continuous flashes of lightning inside towering columns of foam.

"Waterspouts!" she blurted. Cutting the cable on the ocean sounder, she banked the *Magic Dragonfly* into a tight turn and headed south at right angles to the course of the waterspouts. She didn't try for altitude but skimmed the surface of the water. The nuclear jets thundered in as the fans faded and some of their irreplaceable monopropellant fuel poured into the afterburner as Arielle accelerated the plane to top speed. There was a thump and a yell from the rear as George lost his balance under the acceleration. Like a rocket ship taking off horizontally, the *Magic Dragonfly* shot forward. A column of foam internally illuminated by lightning moved in front of them.

"Damn!" said Arielle, and threw the stick over. The left wingtip grazed the foamy tops of the waves below, then swung upward again as the right wing dipped. They missed the first spout, but a second one rose up above them and dumped its load of water in their path. The airplane shuddered as it hit the cloud of huge droplets. There was a loud bang from the engine compartment, then silence.

"The jet heaters shut down!" cried Arielle. "No time to restart!"

The powerless plane started to drop in altitude, perilously close to the tops of the waves. Arielle fired the attitude control jets to decrease their rate of descent. Made for space, the *Magic Dragonfly* would not levitate in 12% gravity. With the rockets fighting off the crash, Arielle brought the VTOL fans up to speed and stabilized the altitude as she turned off the rockets. More precious fuel gone.

She returned her attention to the radar screen just in time to see a tiny twister cross her path. The twister was too close to miss. The right wing of the *Magic Dragonfly* sliced into it and was sucked upward. Arielle fought the controls and almost pulled them out, but the dipping left wing dug into the top of a large wave, spinning them around. The *Magic Dragonfly* crashed heavily into the deep trough in back of the wave.

TO BE CONTINUED

● Anger cannot win; it cannot even think clearly.
Dwight D. Eisenhower

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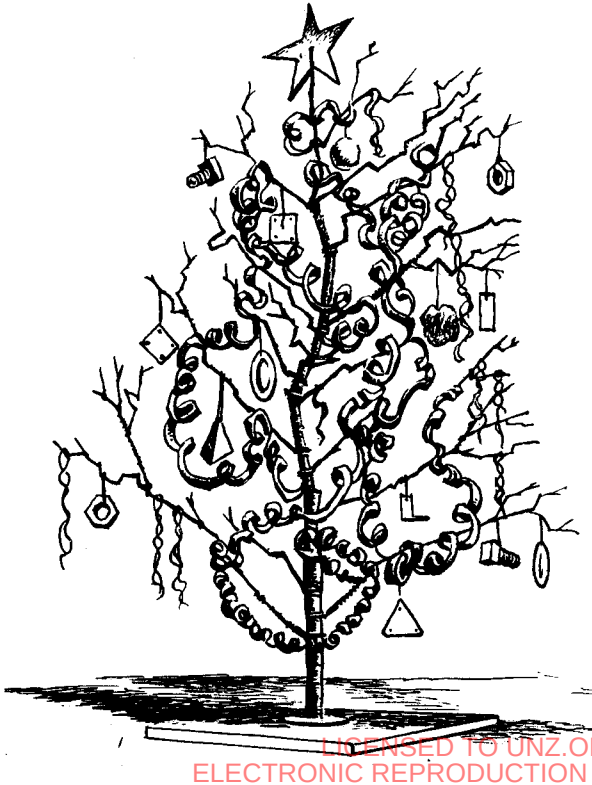
Thomas R. Dulski

MY CHRISTMAS ON NEW HANFORD

Certain kinds of projects are most likely to be undertaken by big, impersonal institutions. But even the biggest and most impersonal consists, ultimately, of individual persons....



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H. R. Van Dongen

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The reason that this may not all ring true is that my name is Bob Cratchit. I hope you'll overlook that. I *was* born Robert James Serber Cratchit on Earth—Jersey Bank, in fact, if that means anything to you—December 2, 3029. More than fifty years ago. And it's been over a decade since I've been back Earthside.

For the last three years I've been here on New Hanford: a largely hollow metal ball about thirty kilometers in diameter, circling a dead world in an uninhabited solar system. And this is the story of what happened here last Christmas. It's not so much my story as it is Pope's and Mehta's—you'll meet them in a bit. In another sense, though, I guess it's my story too. I was there and saw it all happen: a Christmas that I will never forget.

In a place like this, the way you reckon time is funny. With all the dizzying dilations that you go through to get out here, everybody still ends up thinking about what time it is back home. Wherever home is.

For the Snoke—we've got a few of them, mostly in clerical jobs—it was their Season of the Sun. And you'd hear them chanting in the barracks all through the night. And sometimes, when you passed their closed doors, you'd smell something like incense, only with a hint of burnt sugar to it.

Last week the Capellan Freeman who heads the decon crew in A Sector failed to report for work. I found him two hours later hanging upside down by his knees from a ladder rung. Something to do with a holy day of penance. You don't say much in cases like that. We're a mixed lot of misfits in a place where none of us wants to be. If it helps people to deal with their situation by pretending that they're home, you let them. You have to.

For me, it was Christmas. A day that meant something. And by my reckoning and with a little help from some navigational tapes, I calculated that tonight was Christmas Eve.

Since I'm a senior materials engineer, I get a little more privacy than some at New Hanford. And a lot less than some others, I might add. But anyway, I dismissed my crew a little early today and headed straight for the barracks area to set up a little tree in one corner of the metal closet that was my private refuge. It wasn't a tree exactly—just a reasonable facsimile that I programmed a polymer fabricator to produce. I decorated it with little bits and pieces of colored plastic that I found in the fabricator's discard bin. One looked a little bit like a star, so I put it at the top of the tree.

It smelled of outgassing monomer rather than pine, but it looked like a Christmas tree—at least to my tired, nostalgic eyes. I didn't show it to anyone at first, savoring in solitude this little image of home. But I knew that with all the Earthers on New Hanford, there were other trees in other rooms. Many of them.

As I said, everyone who works here has his own way of pretending that he's someplace else. It helps in maintaining the belief that we'll all leave this metal ball alive. New Hanford is isolated from the civilized centers of the galaxy for the good reason that it could turn into a very bright nova if one of us makes the wrong move.

My guess is that you've never heard of Project Grendel. Few people ever

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have, outside of the highest military levels of the Near Arm Alliance. We're building a bomb out here—a "weapons system," as the technical memoranda refer to it.

For centuries there had been talk about the antimatter bomb, the annihilation bomb, call it what you will. The popular press would be full of it from time to time, while the scientists scoffed at the idea as a technical impossibility. Now, finally, that nightmare was about to become reality.

The thermonuclear threat, which began in the twentieth century, held mankind on the brink of extinction for a hundred years, until he escaped to the stars. Once his seed had been sown on a hundred worlds, the race of man would live forever. So the epic story went.

But man doesn't seem to evolve fast enough. Despite all the courage and self-sacrifice that marked our path to the stars, despite the humility we've learned from a first-hand confrontation with the universe; despite it all, God help us, there was Project Grendel.

The Near Arm Alliance was originally established two hundred years ago as a loose hegemony of colonies which looked to the Earth's government for economic support and as arbiter in territorial and resource allotment disputes. Threats from alien races and natural disasters brought a quick response from the fast ships of Earth's military and, in time, the military were given sole responsibility for the colonies. It was a big job, overseeing the governments of nearly fifty worlds—a job, some argued, not suited to the military mind. Gradually, the grip of the military had tightened. And soon what most people on Earth knew of the colonies came through them.

Now twelve far-flung colony worlds were seeking independence from the Alliance. A few had even aligned themselves with alien races against the rest of the Near Arm. The military responded with dispatch: blockade and reprisal against the rebels, martial law for the loyalists, and a massive propaganda campaign for the Earth. The Earth government was taken in completely, supplying men and resources to the cause. But murmurs grew amidst the Earth's populace, as stories leaked back about what was really happening among the stars.

The military leaders of the Alliance felt their grip slipping. Their forces were spread too thin, fighting global wars on twelve fronts, with supply lines thousands of parsecs long. The rebel colonies fought with the dogged determination of people who had prevailed against all adversity on a new world. Underground movements were beginning to spring up against the martial law governments among the remainder of the colonies. The Alliance was crumbling. Something had to be done quickly.

And thus Project Grendel was born.

Create a bomb of such enormous explosive power that dropping it into a sun would swell the corona, engulfing all the inhabited planets. It was a terror weapon, designed as a threat which would bring the twelve rebellious colonies into submission. Not even the military planners talked about it in any other terms. Though what they would decide in the face of continued defiance was anyone's guess.

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Not a pretty thought at any time—this unpopular war and the secret plan for bringing the colonies to their knees. But the Christmas season seemed to bring the situation out in stark relief in my mind. We should have learned our lesson by now, from all the planet-bound wars and from all the men who had died in the name of peace. Instead, we had begun it all again—this time among the stars. I was ashamed for us. And I was a part of it—a shift supervisor at New Hanford. A dealer in death.

New Hanford was designed and constructed for Project Grendel. In part, it was a processing plant for the production of what had come to be known as "weapons grade" antimatter. Primarily that was positronium gas and antinickel, although we could re-tool for the production of any handleable antielement. In another sector we assembled the accreted antiatoms from accelerator targets into milligram spheroids. Finally the spheroids were assembled into an annihilation mass that constituted the bomb. The first of these was now nearly ready: five kilograms of antimatter magnetically levitated in the center of a three-foot steel-jacketed vacuum chamber. It represented a potential annihilation reaction of almost a million terajoules. Its name was Tiny Tim.

The interior of New Hanford was largely a maze of magnetic-walled chambers controlled remotely from processing cubicles where manipulator arms were used to move the material through the process. Hundreds of delicate bubbles, each holding its deadly burden in a balance of force, were coaxed along each working day. And if just one would burst, we would make a bang which would be seen in the night sky back on Earth.

Cargo ships bringing supplies came no closer than the fringes of this solar system—just close enough to launch a reaction engine cargo drone. If someone were lucky enough to be transferred off New Hanford, he left by flivver and rendezvoused with the cargo ship. When new people arrived we sent a flivver out to pick them up.

Nels Mehta had arrived that way two years before. I still remember the look of melancholy on his face as he stepped out of the flivver. Word had it that Dr. Pope wanted him to head up the applied mathematics section of the technical wing. What Pope wanted, he got. Mehta was a luminary from the University on Antares VII—an expert on Lie groups —though not quite on Pope's level of superstar status. I was standing on the gantry support at the edge of the welcoming crowd when the escalator brought him down. He had an amazingly young face for a man who had been teaching for forty years. A dark complexion and deep-set, almost black eyes. He had looked about him as he stepped away from the moving steps and said: "So it has come to this." Pope and the others from the theoretical section converged on him then with handshakes and smiles. I don't think anyone heard the remark but me.

Mehta was a quiet sort who kept his distance from most of the workers and engineers. From what I understand, he had plunged into the work with an intensity that surprised even Pope, though whether that was from intellectual interest or a need to keep himself occupied, I couldn't say. If it was the latter,

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it was a typical syndrome at New Hanford. A large part of our high productivity here is born from fear and a desire to keep our minds engaged.

The workers at New Hanford all are highly trained and psychometrically screened. Everyone from the maintenance crews to the theoretical physicists has at least a Level 9 Clearance. The *crème de la crème* of training, loyalty, and stability. At least that's what the security memoranda from Arbor's office are always saying. I haven't mentioned General Leslie Arbor yet. Officially he's Project Director, this being a strictly military operation. He's fiercely loyal to the cause of the Alliance, of course. A huge guy, bordering on the obese, with a keen mind. He's a crude and unmannered son-of-a-bitch—a marked contrast to Pope. I sometimes think that he delights in the effect his boorish demeanor has on the delicate sensibilities of some of the academic types in the theoretical section. Pope, himself, is a notable exception, though—the two of them always seemed to get along famously.

Anyway, as I was saying, the official documentation would have you believe that all was well among the workers at New Hanford. Actually, they've had a lot of problems here over the years. Strictly not for publication, of course. Arbor wouldn't let anything out that would tarnish his record. In fact, the turnover rate has been five times what the records show.

The escape-hatch training that's required—that might be part of it. Some people never adjust to that feeling you get when you hurl yourself headlong into a kinefax hatch and rematerialize in an air blister on a nameless asteroid half a parsec away. No one really believes that if a magnetic bottle should fail, there will be time to react. Or that if you *do* make it into the hatch, that you'll ever rematerialize, as the raging annihilation destroys the kinefax mechanism. It's just an exercise in futility but, like the ancient centrifuge training for spaceflight, a constant annoyance.

They've had some people crack up, and everyone was issued hand weapons for a while. But that made matters even worse, so they recalled all the hand weapons. Then Arbor got the idea that the workers here were too smart for their own good. The "eggheads" in the theoretical section, Pope and the rest—those he knew he had to put up with. But the rest of us, the workers and the operations people . . . there he thought he could do something. We thought too much about the danger, about what the wrong move with one of the bubbles could mean. So he brought in about a hundred retarded people to do the more dangerous but largely routine jobs. The only stipulation was that those chosen for work at New Hanford must have no impairment of manual dexterity. That was over a year ago and many of them were still here last Christmas.

He hadn't found the answer though, because they seemed to be just as scared as the rest of us.

On Christmas Eve I had a beer at the canteen with one of them. His name was Mike Dobbs and he worked in the neutron scrubbers. His eyes were deep blue and he was almost bald. There was a mustache of beer foam on his upper lip. "Hi, Cratchit," he said, looking up

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from the beer mug as I came in. "We lost a man today, did you hear?"

"No," I said. "In your department?"

"Ise-tope recycle. Little guy—whaddya call . . ."

"Dwarf?"

Dobbs pulled on his drink, wiping his mouth with his fist. "Yeah. Name of Blygh. From Necco's Peace, I think. Ever hear of that world?"

I nodded, punching for a beer and sitting down at the table. "What happened?"

"Cancer. In the guts." Dobbs punched a finger into his stomach.

"Didn't he take his shots?"

Dobbs just shrugged and drank deeply from his mug, but I detected a shiver run through him. And through me.

But tonight was Christmas Eve and I wasn't going to let myself think about those kinds of things. I finished my beer with some idle conversation about the cribbage tournament that would be held in the Rec Hall that night, then got up to leave as Dobbs was punching for another beer.

As I said, I had knocked off work a little early today. I had told my crew that we were ahead of scheduling (we were). And that Production Planning wouldn't like to see a bigger than normal bottleneck of semi-finished antimatter in B Sector just sitting there waiting for sinter and sizing in C Sector. That was a lie—C Sector was ahead of schedule too. Everyone left gratefully and with hardly a word. The control cubicle of B Sector had quickly emptied.

Leaving the canteen, it suddenly occurred to me that I had been in such a hurry to set up the ersatz Christmas tree in my room, that I had left B Sector without securing the control room. Sighing with resignation, I set off down the long metal corridor that led to Operations Control.

The control cubicle was dark and silent. A hundred remote manipulators, each connected to some specially shaped magnetic field, hung from the ceiling like the dead limbs of a metal centipede. Banks of green lights stretched out on both walls of the room, diminishing into the distance like a star field. I was reaching for the light switch, when the stale smell of tobacco reached my nostrils. I stepped over to Albrecht's monitor console, knowing that I'd find a cigar stub in that cut-off tin can that he insisted was a rest for his coffee cup. There was a rush of air as I tossed the stub into the personal waste disposer. He knew that he wasn't supposed to smoke in here. I was going to have to talk to him about smoking on the job. He would be pissed.

By now my eyes had adapted to the dim light and I decided to forego the overheads, walking down the rows of controls and monitors, checking the status of each board. As usual, Mudge, the giant from Rigel IV, had left his enormous green tassel cap hanging over one of the magnetic grapple arms at his station. O'Doyle, next to him, had been doodling pictures of women on his scratch-screen. My footsteps sounded hollow in the long, empty room.

I couldn't shake from my mind how the banks of green lights in that darkened control room looked like a field of stars. Like a Christmas I remembered. A Colorado Christmas when I

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was a boy. My father had taken us in the flivver to a high place in the Rockies where you could buy real Christmas trees. I guess it was the first time that I'd ever seen the stars through a clear sky. I remember that we paid a lot of money for a scrawny little tree and were carrying it to load in the flivver when I looked up. The whole Milky Way was draped across the sky. The depth of it! I thought it would sweep me off that mountain. A sky so beautiful that even now it hurts to think of it.

I had reached the far end of the control room still lost in thought and now I noticed that I'd walked right past Simpson's station, where a red light was winking. I walked over in the silent dark and snapped on his monitor screen. The monitor showed an empty metal chamber surrounded by field coils. It didn't sink in at first. The light indicated a failure in the magnetic power supply, but all of the working bubbles would be empty now at the end of the work shift. *All but Simpson's, of course!* I felt a hot rush of blood to my face. Simpson's bubble was where the day's work was stored prior to transfer to C Sector.

My head reeling, I checked to be sure that I hadn't mistaken the monitor console for some other. No, there was Simpson's nametag fixed to the side of the unit.

My God, I thought, *There was 300 milligrams of antinickel there two hours ago!* C Sector wasn't working a second shift, I was certain.

That meant that someone had taken the antimatter.

It was the kind of nightmare scenario that haunted everyone at New Hanford. Some tightly drawn string among the thousands of people here snaps. Or, possibly, some sleeper agent infiltrated from the colonies receives the call to action.

Whoever it was knew hot-work procedures and had a plan, that was certain. The antimatter had been transferred to a portable bubble before Simpson's chamber field was cut. Otherwise, right now, New Hanford and I both would be a memory.

I was already moving, as the full realization began to sink in. I locked B Sector with my coded ID badge and jumped into the decon-monitor. The metal archway clicked on, giving me the once-over with its whole-body scanner. I could feel my pulse rate rise as I waited for the thing to go through its cycle.

Even though the antimatter we produce stays bottled up in vacuum and by intense lines of magnetic force, the constant monitoring of personnel is essential. The accelerator targets themselves are super-hot stuff and there's the fusion power sources for the magnetic generators. And last, but by no means least, there's the constant flux of hard radiation from the annihilation of stray gas molecules in the magnetic cells, where a vacuum, no matter how good, is never perfect.

After an interminable half-minute, some algorithm in the monitor was satisfied and snapped open the locked door to the corridor. In an instant I was through the door and running. I raced past some Capellans on an off-duty stroll who gave me some strange looks, but the hallway was otherwise empty.

This was not something for a holo-

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phone circuit, I realized, punching the elevator button for the security level.

Major Nicolle Lanson looked up from her desk as the elevator doors opened. "Cratchit," she said, "you look like you've seen a ghost."

"I've got to talk to the general!"

She eyed me with that studied calm that seems to be endemic to career officers in the intelligence branch. "Just what seems to be the problem?" she asked and waved me toward a chair.

I remained standing. "I think you'd better let me talk to General Arbor," I said. Her lips turned up in a patronizing smile. ". . . because some antimatter is missing from B Sector," I finished with a gasp.

The smile evaporated. She mumbled something into an intercom and then led me through the big double doors.

Arbor glared at us from across an immense desk of polished steel. "Cratchit, you better be right about this!" he said by way of greeting. "If this is an accounting or scheduling foul-up, I'll have your ass!"

I regarded the scowling face, the wrinkled uniform stretched over the rotund form. "No, sir," I said, actually hoping I was wrong. "This is a real situation."

"All right," he said, "give it to me in three sentences."

I told him what I knew.

"So you closed down your shift without a final systems checkout." His gaze narrowed down into a deathray.

I swallowed nervously, but held my ground. "The finished work was at Simpson's station at the close of the shift," I said. "I signed the audit sheet at 1650 hours."

Major Lanson was standing close, I noticed—probably in anticipation of an order to place me under arrest.

"You're a civilian defense worker, Cratchit," Arbor said, his voice menacingly softer. "But I think you know that you could find yourself in the army pretty damn fast. . . ." He stared at me for several seconds in silence, letting it sink in.

My gaze drifted up to the bronze plaque on the wall behind him: "Grendel Is Coming/God's Wrath He Bears." It was from something called *Beowulf*.

"If I hadn't gone back there a couple of hours later," I told him, finally, "we still wouldn't know the stuff is gone."

Arbor glared at me a moment longer. "Okay," he said, snapping into a different mode, "we've apparently got a serious problem here. Major, I want an immediate full alert status of all security forces. Systematic Class A search of all levels—" Lanson snapped to attention—"immediate suspension of all recreational activities . . . all civilian and nonessential military personnel restricted to quarters until further notice. I want all Sector B personnel brought in for questioning."

He shot me another withering glance. "That includes you, Cratchit."

"General, if I might have a word with you . . ." It was Dr. Pope, the familiar calabash pipe in his teeth, poking his head in the office door.

"Come in, Doctor," Arbor said. "Something has come up. . . . Major, you've got your orders."

"Yes, sir," Lanson said, saluting and spinning on her heels to rush out the door, almost knocking Pope down.

I studied Pope's face as the general

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related the emergency. An occasional puff on the clay pipe, while the gaunt features remained impassive. Dr. Richard Pope was a cool customer—everyone knew that. In my three years at New Hanford I had yet to see him lose that imperturbable detachment, even for a moment.

Word had it that his graduate students had worshipped him as some sort of demigod back on Earth. Some had even taken to sporting the almost comical calabash that had become his trademark, though few could match his knowledge of the arts and humanities, or his razor-sharp wit.

A Ph.D. in theoretical physics at the age of 23, a full professorship two years later, followed by the directorship of the sprawling Bethelab at L5. The cover of the millennial issue of *Physics Today* had depicted a clay pipe resting on the edge of some massive cooling vanes of an antimatter accelerator. It was all the identification the readership needed—Pope was, indeed, a superstar. Then he had suddenly disappeared from public view. The intelligence branch of the Alliance had circulated a story that Pope was engaged in some advanced design for a hyperdrive starship engine. In fact he was put in charge of building the annihilation bomb.

Pope had picked the site and supervised the building of this artificial world that came quickly to be known as New Hanford, after some reference from the remote past. He had scoured the galaxy for theoretical physicists with whom to populate the technical wing. Many of those awestruck grad students now found themselves reunited with their former professor, but in a strange new context. Still, the veneration remained—even here—where I had seen *"Habemus Papam"* more than once scrawled as graffiti on a wall.

". . . and, of course, I'm going to have to interrogate the theoretical section," Arbor was saying. "We have dossiers on a few of those guys in your brain trust that have given me some sleepless nights, Doctor."

Pope produced a pipe tool from his vest pocket and poked at the ashes in the huge bowl of the calabash. "It would seem to me, General, that the immediate problem is the recovery of the antimatter. You know, if someone . . . for whatever reason, would wish to see this facility destroyed . . . at the forfeit of his own life, say. Why, all it would take is to . . ." Pope snapped on his lighter and puffed his pipe back to life. ". . . pop the bubble, as it were."

Arbor glared at him, but remained silent.

"I have some notions about this," Pope continued calmly, as if he were musing over a problem in charge conjugation and parity. "I'd like to take Cratchit here along and have a little talk. It's just possible that we might come up with a quick solution."

"This is a security matter, Doctor. I suggest you return to your quarters and stay there until . . ."

"Until this facility . . . pops, General? It would be a rather good small-scale simulation of the primordial Big Bang, you know. No, I think Cratchit and I might be able to do some good with a little private consultation." Pope blew out a wreath of acrid-smelling Latakia tobacco smoke and regarded the

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general with a patient smile. "Surely, you don't suspect the two of us?" he said. "After all, Cratchit reported the missing material, and I think you know that I have a rather large stake in the success of this project."

At this point my head was still spinning. I had no idea what Pope could be getting at, but I felt a minor wave of relief as I saw the general relent a bit. "All right, Doctor," he said, getting up with a grunt from behind his desk. "We need ideas right now. But make it fast and don't interfere with any of the security searches in progress." He tapped a forefinger forcefully on the desktop. "And don't take any action on your own! Here, I'll give you a pass that'll get you past our checkpoints." He scribbled something on a notepad and thrust the slip at Pope.

I followed Pope numbly out of the office and into the elevator. When the doors had slid shut, he said: "Have you had your dinner yet, Cratchit?"

The worker's mess hall was completely deserted, the tables littered with abandoned meal trays and glasses. I wasn't really hungry, but shrugged and punched for baked ham. What I got was chicken soup. I didn't see what Pope selected, but he got the same. The cargo ship had been late again this month. We cleared a space at one of the tables and sat down.

"The general's not a bad sort, really," Pope said.

I took a spoonful of steaming noodles and remained silent.

"He's genuinely convinced that the Alliance is our last hope for maintaining a continuity in the culture of the human race."

I wasn't sure how to reply to that.

Pope stirred his soup reflectively. "You know, Cratchit, people like us—the scientists and engineers—we come at this thing from a different perspective from the military. The technical challenge—that's the key. We don't tend to dwell upon the implications of the work. . . ." He sipped at some of the broth. "I don't think I've ever asked you how you came to our tight little island in space?"

It seemed an oddly casual tone in light of the situation, even for Pope. "Ah, I was conscripted from Driworld," I told him. "I helped to design some of the 114 refining plants there. We were gearing up to supply other superheavy elements, but I never saw that through."

His gaze lifted from the soup bowl, and I realized what some people had said about those penetrating grey eyes. "You're originally from Earth, aren't you? Was Driworld your first assignment?"

"Second." I said. "When I graduated from Carnegie-Mellon I took a job with an engineering company that was building water recovery plants on a little colony world called Hasper—you've probably never heard of it."

"That's out in the system that used to be called Luyten something or other, isn't it?"

I was once again amazed at his eclectic memory. "Luyten 789-6," I said. "It's 11.2 lightyears from Earth. I guess I picked up a good bit of useful information about fusion-powered generators out there. That was before the war, of course. Look, Doc, you said . . ."

"And how did you get to Driworld?"

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Pope seemed insistent on steering the conversation.

"Well, after seven years on Hasper the company transferred me to a project on Driworld. Hasper was a small frontier colony, but Driworld was a lot different—a heavily populated dustbowl. The air was bad and the ground wasn't much good for growing food, but it had a rich supply of superheavy elements. It was the presence of those Supes, as we called them, that swelled the population. I was sent there to set up water reclamation systems in some of the smaller cities. After a couple of years the war broke out and I was reassigned to Supe refining. It meant a draft deferment, so I wasn't really upset about it. And I got to learn a lot of state-of-the-art technology." I also remembered that I had been naive enough to believe in the war back then and I had really wanted to contribute my part to the effort.

Pope ate his chicken soup in silence, while memories from that earlier time swam before my eyes. There had been a Christmas there on Driworld, with a tree. Some old codger of a senior engineer had smuggled one through from Sylvanburg when his liner had stopped there for refueling. It wasn't really my idea of a pine tree, but it was green and we had decorated it with photodiodes. I remembered that we drank brandy and sang Christmas carols. Even some of the Snoke had joined in. Late in the evening I went over to the barracks window. The air was remarkably still and the afternoon dust had all settled. The stars stood out like bright pinpoints. After a few minutes I found it—Earth's sun. I brought over each of the engineers and pointed it out to each in turn. And then Jergins, the old guy who had smuggled in the tree, proposed a toast. And we drank to home and Christmas under the light of that star.

"So you came to New Hanford from there?" Pope said, breaking the quiet.

"The war got worse the next year," I said. "Draft deferments went from semi-annual to monthly. The Supes had some limited military use. Primarily they were interested in element 114, but most of those refining plants were already in place and operating routinely. All the engineers in my barracks were worried about the draft. When my transfer to New Hanford came I never saw any of them again." Silently, I wished them all luck, wherever they were.

Pope dropped his spoon on the tray and reached into his jacket pocket for the calabash. "A very typical story, Cratchit," he said, filling his pipe from a rolled leather pouch. "This war has made orphans of us all, I'm afraid. I've left a wife and two children to come out here and build their monster for them . . ."

Pope was interrupted by the sound of running footsteps in the corridor—a detachment of soldiers on a security sweep. A sergeant with a drawn hand-weapon stepped through the doorway. "Dr. Pope . . ."

Pope waved the slip of paper Arbor had given him. "Everything's in order, I believe," he said, lighting his pipe while the soldier scrutinized the note.

Arbor's scrawl seemed to produce the desired effect. "Yes, sir," the sergeant said as he handed back the note. "Don't lose this, sir." He disappeared out the

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doorway and the tramp of feet diminished down the hall.

The intrusion had brought me back firmly to the present. All our lives were hanging by a thread, and Pope so far seemed only interested in hearing my life story. "Doctor Pope, you said you had some idea about who might have taken the antimatter. . . ?"

Pope puffed on his pipe thoughtfully. "Mm, yes I did, didn't I? You know, Cratchit, this isn't a very popular war the Alliance is fighting. There are many people who feel that those twelve—I think it's twelve now, isn't it? That those twelve colonies deserve their independence—the right to pursue their own destiny. . . ."

I looked about the empty mess hall despite myself. That was not the kind of talk one expected to hear at a defense installation. Particularly not here at New Hanford. And especially not from the technical director of the project.

Pope smiled at my unease. "Come now, Cratchit. Of course the room is bugged, but the general has heard all this from me before. I am merely stating the facts. 1984 was more than a thousand years ago. Though I must confess that General Arbor would make a passable modern version of Big Brother."

I didn't get the reference at the time, but I was familiar with Pope's habit of throwing out literary allusions. It certainly did nothing to calm my nerves. I began to wonder if maybe Pope was testing *my* loyalty. "Look, Doc," I said, "I'm as glad as the next fellow that I'm not fighting on the front lines, but I believe in the war and what we're doing here." That was a crock and I was pretty sure Pope knew it, but it seemed the best thing to say, especially if Arbor was eavesdropping.

Pope blew a ragged smoke ring. "I wasn't suggesting otherwise, Cratchit. My point is that we have here at New Hanford a diverse collection of over two thousand five hundred individuals with all sorts of perspectives on the cause of the Alliance." Again he fixed me with that penetrating grey-eyed stare. "Don't you feel that some among them might sincerely feel that what we are doing here is morally and ethically wrong?"

I shifted my gaze to the tabletop. "Well, sure," I said, "we know that there's one at least. Whoever took that antimatter from B Sector."

"I'm not talking now about an agent from one of the colonies, political sabotage, that sort of thing."

He seemed to be trying to mix up my words. "Look," I said, "sure it could have been a spy from the colonies. It could have been some sort of pacifist or anarchist. What do I know about these things! Doc, what are we talking about here? What's your point?"

Pope was silent a moment, though I could feel his gaze as a tingling on my scalp.

"You know, Cratchit," he said at last, "people choose a career often for the oddest of reasons. . . ."

Another strange shift from this very strange man. I looked up at him. "How do you mean, Doc?"

He removed his pipe and studied the wisp of smoke trailing from the stem. "Take me for example. I became interested in physics as a young man because of . . . this may sound odd to you. Because of its poetry. In elementary school—an otherwise dreary place

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on the lower east side of La Guardia Terrace—I remember how the *music* of the subject caught my ear. Particles with strangeness, charm, truth and beauty. The Eight-fold Way, flavor symmetry, the Five Petals of Unified Gage, the golden comb of topology . . . It sounded like a magic language with which one could speak to God. So I became a physicist. Perhaps that was a mistake."

"You've done pretty well at it."

The thin face now looked a little wistful. "Not really, Cratchit. The truth is that I've been a dabbler, with a certain talent for organizing and directing the work of others. I'm a better critic than a creator. If I've contributed anything to our knowledge, it's been by keeping the others, the original thinkers, intellectually on their toes and true to their gifts."

He sounded very sincere, but I couldn't fathom why he was telling me this. "Everyone admires you, Doc," I said and meant it.

There was another long pause in which he seemed to be lost in some inner realm of thought. Then he said: "If I'm to earn that, it will not be for physics."

He looked at his watch and when he looked up he was almost smiling. "Possibly that time has arrived," he said. "Cratchit, shall we take a little walk?"

He had already gotten up and was knocking his pipe ashes in the empty soup bowl.

"Where are we going?" I asked, surprised by this sudden decision.

"Come along, Cratchit," Pope said. "A little stroll will clear the cobwebs."

I followed him out into the corridor and we started off in a direction that led toward the Health Physics Sector.

This place, New Hanford, takes some getting used to even when it's full of people. But now, with the security alert in effect and the rooms and halls devoid of life, the impression it produced was somber and frightening. Somewhere, I knew, in this labyrinth of echoes and empty rooms there was a desperate man holding all our lives like a bubble in his hands. I walked beside Pope, listening to the hollow click of our steps, trying to imagine just what sort of "notion" he had in mind.

We were stopped at a corridor intersection by a tense-looking guard. Pope again produced the note and we were allowed to pass without a word being exchanged. I still remember how young and scared that guard looked.

The Health Physics Sector is a huge part of New Hanford. It was in this area that worker training was conducted on cold cell simulators: a microcosm of the entire processing facility, lacking only the hot targets and the antimatter. Classroom training was provided in three large amphitheater-style lecture halls—we were passing the array of large double doors now. One of the doors was already marked with a placard for tomorrow's lecture: "1330 hours—Redundancy Systems, Maintenance and Testing."

The next group of doors were examination rooms and laboratories where the regular worker physicals were conducted and blood and urine samples analyzed. Everything was locked and silent.

Pope strode on just as if he knew exactly where he was going. Neither of us had spoken since leaving the mess hall. Finally I broke the silence in a loud

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whisper: "Doc, I wish you'd tell me what you have in mind."

He silenced me with an upraised palm, stopping before one of the doors. It was the kinefax training facility, where the workers were drilled in emergency evacuation procedures. Like most people on New Hanford, I hated the place.

Pope glanced up and down the deserted hallway, then produced a ring of magnetic keys and unlocked the door, ushering me into the pitch-dark room. There was no light to adapt to, just a faint whine of machinery and absolute blackness. I stood still, sweating, as phosphenes danced before my eyes. There was a sharp click as Pope locked the door behind him.

The light snapped on, blinding me for an instant in its glare.

"Hello, Richard," someone said.

"Hello, Nels," I heard Pope answer. "How are you feeling?"

My eyes focused on the short swarthy figure standing about two meters away. It was the mathematician, Nels Mehta.

"I'm tired, Richard," he said, "very tired."

Mehta was coatless, his neck-scarf loosened, shirt sleeves rolled. Next to him . . . My eyes widened in disbelief. Next to him on its heavy-duty levitator pallet was the steel egg New Hanford had laid: Tiny Tim.

"Did you disable the microphone and camera?" Pope asked, almost casually.

Mehta nodded. "The infrared circuit will get a tape loop of an empty room." The mathematician indicated me with a toss of his head. "You brought Cratchit along to help with the bullwork, eh?"

I looked at Pope, then back at Mehta. I can't imagine what kind of expression was on my face.

"Yes," Pope said, "I think the three of us might just manage it. What do you think, Cratchit?"

My mouth was working but nothing was coming out.

Pope walked over to the kinefax trainer and stood beside the gaping orifice of the machine. "You know, Cratchit, this is an interesting device. We have hundreds of these all over New Hanford, yet as with so many of the tools that man has built, we remain really quite ignorant about the deepest physical laws upon which they are based." He patted the generator cells above the opening. "We know the kinefax disassembles matter—men, machines, whatever—and transforms it into a coded beam of energy, then instantly reassembles it at a programmed destination. Instantly, Cratchit. A transmitted clock doesn't lose or gain a single tick—quite in defiance of a number of our most treasured prejudices about the way the universe works.

"The beam does not pass through the intervening space, but it predictably appears at its destination point. There are quite a few theories about where that beam goes when it leaves a transmitter and arrives at a receiver. One of the theories suggests that—and here I have to use some terms from that magic language I referred to—that the beam propagates through a dimensional horizon. That's sort of an interface between . . ." He waved his hand in a sweeping arc. ". . . this universe—all we can see and know—and . . . someplace else. In another sense, the beam passes through a

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symmetry interface. Like combing the hair on a billiard ball, ungraspable except in terms of golden comb topology.''

Mehta stopped him. ''Richard, I think we'd better hurry with this.''

''In a moment, Nels. You see, Cratchit, some studies were done this past year. We weren't at all certain what would happen if we attempted to transport antimatter with the kinefax. We tried it with some small microspheres last month. The magnetic generator arrived intact, its field still operating. But the antimatter was gone—vanished. We believe now that it was drawn into that . . . someplace else that I mentioned. Perhaps, it's a universe of antimatter, where matter is as rare as antimatter is in ours.'' Pope spread his hands. ''We just don't know. And we may never know.''

''Richard . . .''

Pope nodded. ''Yes, Cratchit, Nels is correct. Time is of the essence here. You *will* help us get rid of this stuff, won't you?''

This was all going too fast for me. I waved my hand helplessly at the levitator pallet and its monstrous burden. ''G-get rid of the bomb . . . ?''

Pope peered in the opening of the kinefax. ''Well, yes, that seems to be all that's left. I see that Dr. Mehta has already loaded the semi-finished material, including that 300 milligrams from B Sector. Here, now, Cratchit, lend a hand,'' he said, moving toward the steel egg. ''This thing is quite heavy even with the aid of a levitator.''

Numbly, I moved forward and found myself helping to guide the levitator toward the opening.

''There. That should be about right,'' Pope said. ''Now if the three of us push together . . .''

I felt the infernal thing bob in the levitator field as we grabbed hold of it. ''On the count of three,'' Mehta said. ''One, two, *three*.'' It slid off the field and into the kinefax cavity with a loud thunk.

''Very good,'' Pope said. ''That wasn't too bad. Now, Nels, if you would do the honors.''

Mehta busied himself with the control settings on the kinefax.

I must still have had a strange expression on my face. Pope put a hand on my shoulder. ''Now, now, Cratchit,'' he said, ''professional engineer's pride and all that, I know. And it *was* a rather nice piece of work, that bomb. But don't forget, we can build another one in three years or so.''

The kinefax was buzzing now, the generator cells at full power. Mehta was standing at the side of the machine, his right hand on the activation lever.

''Richard . . .''

''Go on, Nels, the moment is at hand.''

Mehta put his other hand to his forehead, his dark brow wrinkling with strain. ''Richard, I think . . . Arbor must have . . .''

Pope rushed over, catching him as he began to swoon.

Mehta groped blindly for the activation lever which had slipped from his grasp. ''No, old friend . . . let me be the one to . . . send away this . . .'' His fingers had found the metal handle, but then his body slumped, a dead weight in Pope's arms.

''What happened?'' I gasped.

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"A scrambler field," Pope said. "It destroyed the personality recording. I was hoping the general wouldn't use it so soon."

I stared with shock at Mehta's lifeless form. "Personality recording . . . Then . . . Dr. Mehta was an android?"

Pope's face looked especially drawn. "Yes. Nels Mehta died two years ago on Antares VII. His recorded personality was placed in this likeness. The general knew about it, of course. I convinced him that we needed Dr. Mehta's expertise, so he agreed to have the simulacrum brought here to work on the project . . . here, Cratchit, hold him, would you?"

Pope shifted Mehta's weight to me. His flesh felt amazingly human. It was still warm.

"The general must be getting edgy," Pope said. "Certainly he knows the bomb is missing by now. He must also know that Nels is not in his quarters. The scrambler field was a desperate precaution." Pope clutched the back of Mehta's hand, which still held the activation lever of the kinefax. "Now, Cratchit. There it goes." He pushed the lever forward.

There was a brief crackle.

When I looked, the interior of the kinefax cavity was empty. Pope cut the power and the machine's whine died. "Well," he said, "so be it. Perhaps we should leave Nels there. Here, let me help you."

We eased the body to the floor, leaning it against the machine. Dr. Mehta's right hand still clutched the lever. "There," Pope said, "that should do it. The general may be coming along shortly. Or perhaps we should call him. . . ." He looked at me and then down at the body of the mathematician. "He was a fine man, Cratchit. A brilliant thinker, but more than that—one of the truly good people it has been my pleasure to know."

Pope reached into his coat pocket and produced the calabash. I watched in amazement as he calmly began to stuff his pipe. As if he had just completed some lecture before an awestruck throng of students. "By the way, Cratchit," he said, between puffs as he lit the tobacco, "I'm sure you'll know what to say when the general questions you about all this."

My head was still spinning, but I found myself with a ready answer: "I'll tell him that Dr. Mehta transmitted the antimatter before we got a chance to stop him."

"Yes. I have some serum for us in case the general insists on drugged interrogation, but I don't think it'll come to that. The sticky part might involve just how Nels managed to manhandle the bomb into the chamber. But the general knows that desperate men find unknown reserves of strength. I'm sure he'll eventually see it that way."

Even thought I was reeling from the events of the last few minutes, I was also feeling good. Some of the enigma that was Dr. Richard Pope was a little clearer to me now, though one thought still troubled me. "How did you know, Doc?" I asked.

"What's that, Cratchit?"

I smiled at him. "How did you know that I'd help you?"

Pope grinned and blew a wreath of smoke. "I told you that I have a talent for bringing out the best in our people."

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He looked at his watch. "You know, if I'm not mistaken, Cratchit, season's greetings are in order."

"Merry Christmas, sir," I said.

Pope and I were in for some rough times from General Arbor, I knew. But I also knew that we could weather that storm. Pope, if they let him, would go on to begin building the Alliance another bomb. And me, I probably would go on as well, helping to accrete the components of a new monster for the general. What we had done that Christmas morning was to buy mankind another three years in which to grow up. I thought it was just possible that this time we would.

As Pope walked over to the room's holophone to call the general's office, I felt a kind of warm joy that I hadn't felt in years.

Three hundred lightyears from home, I thought, *Cratchit, the engineer—a cog in the warworks—did something for peace. Helped, anyway.*

Standing there that Christmas morning, I felt surrounding by ghosts. My father was there, a Colorado spruce slung over his shoulder, his breath a plume of white. And Jergins, the tree smuggler, his brandy-filled glass winking back starlight. And Blygh, the dwarf from Necco's Peace—he was there. And Nels Mehta was there too, his tired face smiling.

Someday the war will be over, I told them. *But for now: Merry Christmas!*

. . . We shall have a rugged time of it to keep our minds open and to keep them deep, to keep our sense of beauty and our ability to make it, and our occasional ability to see it in places remote, strange and unfamiliar. We shall have a rugged time of it, all of us, in keeping these flourishing in a great, open, windy world. And in this condition we can help, because we can love, one another.

—J. Robert Oppenheimer ■

● As happens occasionally, the cover of our next issue will not illustrate any story within; we present it to you as an example of Art for Art's Sake. We won't describe it, except to say that it's by California photographer Ctein, whose color work of objects both natural and manmade has received widespread commendation.

January's lead story will be "Taking the Fifth" by Hayford Peirce, whose last *Analog* piece appeared in 1977. His new novelette concerns the effects of a certain scientific development upon the U.S. judicial system. And we'll bring you Parts II of *Rocheworld* by Dr. Robert L. Forward and "The Blivit in the B-Ring" by Richard C. Hoagland, as well as several pieces of shorter fiction.

IN TIMES TO COME

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Jay Kay Klein's biolog

It's not every first sale that becomes a cover story in *Analog*. "The Trelph Is A Solitary Creature" managed that feat for Thomas R. Dulski just one year ago in the the December 1981 issue. Not that Tom is a brand-new writer—he's been writing off and on since his teens, so it is no wonder his first published story shows all the marks of a polished craftsman. The story also centered around something Tom is familiar with: unusual chemical reactions of unusual substances.

Tom has been an analytical chemist in industry since his graduation with a B.S. in Chemistry from the University of Pittsburgh. He was born in Pittsburgh and started work there, but has since moved to Reading, Penn. As you might expect from a science fiction writer and someone who would come up with that title for his first story, Tom hasn't simply been doing routine titrations according to a chemist's cookbook. Most of his working time is involved in developing new analytical methods. Seven of his papers on the results of his exploration into new areas have been published in technical journals. By the time you read this, the most recent will have appeared in *Talanta*, an international journal of analytical chemistry.

Thomas R. Dulski

In case anyone wonders just how easy it is to put together a hard science story to suit *Analog*'s editor, it took Tom's professional background to prove mathematically that the key plot elements in "Trelph" actually were possible. As a professional physicist, Dr. Schmidt thought the convoluted pathway to nuclear fission of fissile fish just might prevent a nuclear reaction from taking place.

Tom's not a science fiction fan; has yet to attend his first convention. He's been a reader, though, since his teens. A brief list of his favorite writers would show both classic and contemporary authors, both hard science and humanistic. He feels that one of the unique resources of science fiction is its having much of the older material in print contemporaneously with new work. Furthermore, he thinks it important for a writer to be familiar with what was done in the past so that the more heavily trodden paths can be avoided. Although having a heavy scientific background, he intends to write other kinds of science fiction, too. Significantly, and unexpectedly considering the type of story, the lead character in "Trelph" was a lawyer.

For Tom, the allure of science fiction is its "sense of wonder," representing as it does a universe filled with diversity beyond imagining. Science fiction's role in our culture isn't to get us "out there," since he's sure we're going to get there, anyway. What science fiction will do is make some sense out of that strange universe when we arrive, and make us aware of its importance. ■

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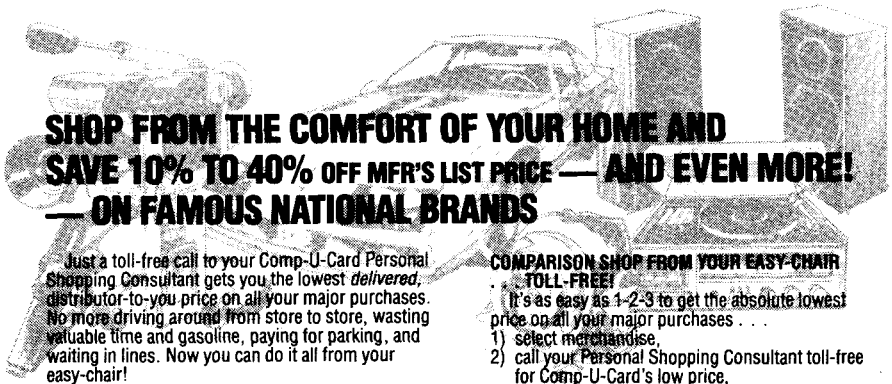

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Richard C. Hoagland

THE BLIVIT IN THE B-RING

There is something very strange in the B-ring of Saturn—and it may be something very important.

As a reader of this magazine for many years, it gives me enormous pleasure to inform you, "We've got a live one here."

There is something in the fabled rings of Saturn, something splashing careless megawatts of radio energy across the night, something orbiting with a period a little over ten hours . . .

And nobody currently knows what it is or why it's there.

That isn't to say there aren't a lot of theories—ranging from a moon caught in the act of *forming* in the contemporary solar system, to the more spectacular: that the object is the first discovered *primordial black hole,* somehow captured by Saturn long ago. There is even the quasi-serious mention (if not a secret hope) that we have finally stumbled across IT—a truly alien artifact, some kind of device still mindlessly clearing ring debris around the strange emitter, for masters who have long since died. . . .

Strong stuff? Yes. But not without a

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fascinating chain of evidence, as you will see.

To properly relate this mystery, we must begin where it began—the Jet Propulsion Laboratory in Pasadena, California, control center for the epic unmanned VOYAGER missions to the outer planets. It was there, just two years ago this month, that scientists began picking up a strange radio transmission . . .

. . . a "thing" broadcasting from the vicinity of Saturn.

Less than a year before these same investigators, members of VOYAGER's Planetary Radio Astronomy (PRA) investigation, had made their first surprising discovery about Saturn: that, despite an almost perfect alignment between the planet's magnetic field and the axis of rotation, an interaction with radiation belts somehow manages periodically to emit very low frequency radio waves. This Saturn Kilometric Radiation (SKR) was used by the PRA investigators to derive a new timing of the rotation of Saturn—as the source was presumably linked to the planet's very core, where the magnetic fields of all planets are thought to be generated. The new rotation worked out to 10 hours, 39.4 minutes.

The "Thing's" radio emissions, unlike SKR, were not confined to very low-band frequencies or kilometer-long waves. Instead they were apparent across the entire width of the PRA receiver's "spectrum"—the total span of frequencies to which the VOYAGER experiment was sensitive. That span—equal to a set of frequencies on Earth corresponding to everything from VHF television transmissions to low-frequency AM radio stations—was filled with random "static," strange bursts of emission apparently emanating from somewhere ahead of VOYAGER . . .

. . . from the vicinity of Saturn.

According to Dr. James Warwick, head of the VOYAGER PRA experiment, "They (the bursts) were like nothing we've seen on Earth before or, for that matter, in the vicinity of Jupiter two years ago. Jupiter has a highly energetic trapped radiation environment that could have triggered all kinds of spurious electrical effects in the spacecraft similar to this. But it did not. Therefore, we conclude that whatever is causing these bursts of intense radio emission at Saturn—equal to a *hundred million watts*—is not coming from defects in VOYAGER's telemetry system, or from the much weaker Saturn radiation environment, but somehow from Saturn. . . . "

Well, not exactly from Saturn.

The energetic bursts would soon be traced to Saturn's unique adornment, that which has made the planet different from all the other planets from the moment Galileo first turned his primitive thirty-power telescope on Saturn over three hundred years ago.

The rings.

It was Dr. David Evans, a young British associate of Warwick's who had just joined the PRA team, who would make the initial crucial discovery about the bursts: they too were highly periodic. But—they would be traced through a recurrent pattern of about five hours "on," followed by about five hours "off"—significantly different from the

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SKR-derived rotation of the entire planet. Whatever the bursts were, they were *not* directly related to the spin of the deep body of the planet. Rather, they repeated in a period all their own—10 hours, 10 minutes, give or take five minutes.

According to Evans, who is better known as "Doc" (testimony to a somewhat British habit of calling people by their first initials—in this case, D. R.), "the periodicity just sits there . . . it leaps out at you."

Evans's admiring colleagues on the PRA team insist that it was Doc's own brilliant statistical analysis of the apparently random salt-and-pepper-looking data which first alerted them that VOYAGER had "heard" a second "something" both puzzling and potentially significant.

This is in stark contrast to some of the other VOYAGER Project scientists, with their own experiments aboard the spacecraft. Some of them (though not the majority) continue to dispute not only the fact of any periodicity, as seen by Evans, but the reality of the phenomenon as anything but "noise somewhere in the immediate vicinity of the spacecraft, having nothing to do with Saturn."

As we shall see, there is now fairly compelling evidence substantiating Evans's claim that the mysterious "object" does exist at Saturn—and that it orbits in the rings themselves.

This was deduced by process of elimination. Comparison of various frequencies of the extremely broadband signal, which behaves "like terrestrial lightning, only a million times more energetic," convinced the members of the PRA team that the signals had to be coming from somewhere in space *near* Saturn. The planet itself seemed ruled out, because the lowest frequency emissions could not have penetrated upward through the ionosphere which surrounds the planet—a layer of electrified molecules and atoms exactly similar to a layer which exists high above the Earth. It is this layer which permits the "bouncing" of radio signals, such as ham radio frequencies, around the curvature of the Earth. The signals, by being reflected back by the electrified layer, are not permitted to escape into space.

If a spacecraft like VOYAGER were to approach the Earth, it would "hear" only much higher frequency transmissions; not the low-frequency signals used by ham operators.

By this analogy, the PRA team reasoned, the lowest-frequency signals VOYAGER was hearing could not be generated beneath Saturn's own ionosphere—they couldn't have escaped to be picked up by VOYAGER's receivers. Thus, the "lightning-like" emissions could *not* be coming from exotic Saturnian thunderstorms occurring in the highly turbulent atmosphere VOYAGER was photographing.

Having effectively ruled out Saturn as the source, Evans turned to the next most logical alternative—an orbit of the planet.

An orbital phenomenon would be, inherently, very periodic. It was simple to identify an orbit with a period a shade over 10 hours. But, once that was done, it was immediately apparent that the

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PRA team had really discovered something: such an orbit was smack dab in the middle of the densest, most spectacular ring encircling the planet, known in the trade as "the B-ring."

The exact distance from the center of the planet (which is the way orbits are calculated) worked out to 1.8 Saturn radii. That distance could then be identified (within the uncertainty of the statistics) by a narrow dark "gaplet" separating two bright "ringlets," in the maze of similar detail which VOYAGER itself revealed for the first time via its television close-ups.

A thought which now occurred to the increasingly excited members of the PRA investigation was simply this: was it mere coincidence that the mysterious emitter had an orbit in the middle of the B-ring—when it was the B-ring itself, the middle of Saturn's three "classically" known halos, which embodied the richest number of exotic, new details?

It was the B-ring which exhibited "tens of thousands" of concentric ringlets to the VOYAGER cameras, aweing everybody with a complexity way beyond any pre-VOYAGER scientific expectation. It was the B-ring which exhibited those mysterious, line-like features lying *crosswise* to the orbital motion of all the other ring particles; features called, for want of a better designation, simply "spokes." And it was the B-ring, which, looking back, VOYAGER discovered to be filled with a large percentage of very fine material, icy flecks of dust a few ten-thousandths of an inch across, arrayed in ringlets of their own and capable of forming, apparently, the spokes—now turned bright, when seen against the sun.

For all these reasons the B-ring was the center of attention for much of VOYAGER's investigations. Now, somehow, it was host to a peculiar source of radio transmission, orbiting the planet in the very densest portion of the ring.

To Warwick and his crew, this coincidence was trying very hard to tell us something about the nature of the rings—if we were smart enough to understand the clues.

What was truly amazing (and disturbing) about this enigma was the fact that there was only "one," one "thing" orbiting and broadcasting its presence via eerie bursts of static, amid trillions of cathedral-sized, house-sized, and, of course, the dustmote-sized debris which make up the rings. Yet, apparently, there was only one of these strange "beasts" lurking in the entire three trillion square miles of surface area represented by the rings, that splendiferous display, falling—like an eternal snowstorm—forever around Saturn.

Scientists don't particularly like "one" of anything—one peculiar star, one abnormal planet, one enigmatic galaxy. Science advances by cataloguing objects and phenomena as part of larger structures or processes already known. "One" of anything makes scientists distinctly uncomfortable, as there is no easy means to compare a unique object with any of the others we think we understand. It forces you back to fundamentals—like beginning with the basic physics of a radio emission process

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which might conceivably take place in that unlikely environment—the rings.

The problem of "the thing in the ring" gives us, then, a rare opportunity to see how science actually performs, when confronted by a phenomenon nobody at present understands, which in fact some VOYAGER scientists still insist isn't even there!

The usual scientific procedure, after being confronted with a set of data as bewildering as VOYAGER's, is to try and build a "model"—a simple picture of what is going on.

The simplest explanation, embodied in the PRA team's name for their phenomenon, was that the signals came from some kind of electrical arcing in the rings. They called it Saturn Electrostatic Discharge—SED.

Producing SED, Warwick and his colleagues calculated in the months immediately following the VOYAGER 1 encounter, required that relatively small (meter-sized) ring particles drift close to a relatively large and massive "moonlet" in the B-ring.

The ring material (composed of ice at very low temperatures) is charged to varying degrees by sunlight, explains Warwick. Via a mechanism still under intense investigation—as to how it might work in practice in the rings—the large moonlet, several miles across, accumulates a rather respectable voltage, perhaps as high as several *million* volts. As random orbit perturbations and small collisions in the densely populated B-ring send "snowman-sized snowballs" into collision orbits with this larger object, their approach to the highly charged body produces a "mirror charge" upon the snowballs.

Within inches of collision it is these induced charges that let loose a devastating electrical arc between the snowball and the moonlet, across the few inches of essential vacuum separating the two objects. A sudden, massive "short"—lightning in the rings—takes place at each encounter, resulting in a burst of broadband radio emission.

Raining pieces of the "intruder" on the moonlet, each encounter was presumed to add material to the central figure in the drama, making up (Warwick reasoned) for some material lost in vaporization during each discharge "event": as much as several pounds. By adding to its bulk from the snowball which chanced to approach too close, the moonlet was presumed to be able to replenish the material evaporated, reaching a condition of so-called "steady state" in only a few thousand years. A handy side-effect of such a process was the constant pulverization of larger ring debris into much smaller pieces—including the drifts of "micron-sized dust" observed by VOYAGER to almost exclusively inhabit the region of the B-ring.

These clouds of icy flecks, blown inward and outward on strange "electric winds" (calculated to cause such tiny particles to migrate toward or away from the planet depending on their own electric charge) would then—somehow—form the spokes, those bizarre B-ring enigmas unique to the central ring about the planet.

It was an image perhaps more appropriate to a "Saturnian Norse Legend,"

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complete with shadowy Frost Giants, Thor's Electric Hammer, and the Bridge of Bifrost represented by the Rings themselves, than to any sober scientific study of the planet Saturn.

Leaving aside Frost Giants or Thor's Hammer for a moment, it wasn't a bad model . . . except for a few small nagging problems.

First, there was the problem (rapidly becoming *the* problem) of explaining once again why there was only one.

In Warwick's initial calculations, the moonlet was presumed to grow as a result of electrical accumulation of lots of smaller ring debris—a process akin to pieces of plastic wrap sticking to a bowl. "There is no immediately apparent reason," Warwick would say later, "why the process should produce only *one* such object. There should be many, scattered through the rings . . . "

The second objection was more subtle.

VOYAGER 1 observed SED both on the inbound leg of its encounter with the planet—as it approached—as well as when it was receding. In fact, the bursts were detectable several days longer on the outgoing pass, as VOYAGER was thrown by Saturn's gravity high above the ringplane of the planet. But that wasn't the problem. No, the surprise was that the outbound signal was clearly *different* from the noises heard on the approach. In the parlance of radio people, the signal was *circularly polarized*, and in a left-hand sense.

"Polarization" is a term denoting the orientation of an electromagnetic wave as it vibrates through space. A "circularly polarized signal" was simply one that "corkscrewed" through space, constantly changing orientation in relationship to a fixed antenna, as the wave traveled forward.

Polarization—of light or radio waves—is often an invaluable clue as to physical processes occurring at the source of emission. For this reason, VOYAGER carried two 30-foot radio antennae—"cat's whiskers"—aligned at right angles to each other. This way both radio investigations aboard the spacecraft—the PRA experiment and the Plasma Wave Science (PWS) experiment—could detect polarized—oriented—signals. Changing polarization was also detectable: as a varying signal in each antenna, as the constantly rotating wave was picked up by first one "whisker" and then the other.

The discovery of polarized aspect to the SED emission was a bit embarrassing: radio emission from electrical discharges should have random polarization, as each electrical "arc" occurred at some random orientation in relation to VOYAGER's antennae. The realization that the signals from the "thing" were clearly circularly polarized, after the spacecraft passed Saturn, had introduced a fundamental—potentially fatal—complication into Warwick's simple model. As Warwick put it:

"In our model, the radiating electrons clearly are essentially relativistic [moving close to the speed of light]. If, as generally seems the case in astrophysics, strongly polarized emissions are diagnostic of the *presence of magnetic fields* in the SED process (italics added),

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then we have as yet failed to identify a plausible field source.''

Put another way: how could a frozen chunk of *ice* maintain a magnetic field?

Warwick's own ingenious answer? The moonlet spins.

It is a well-known law of physics that a moving electric charge mimics a moving current of electricity. Both exhibit an associated magnetic field. (That's why you don't put electrical equipment near a magnetic compass on a boat, or in an aircraft: the associated field will overwhelm the background magnetic influence of the Earth, to which the compass is normally aligned.)

Rotation of a charged moonlet, Warwick calculated, even if the body was composed totally of non-conducting ice, would in essence create a ''simulated current'' around the moonlet's equator. The result would be a magnetic field! Each ''discharge event'' occurring near the moonlet, therefore, would take place within this field. Electrons, leaping across the space between the two interacting objects—the moonlet and the ''snowballs''—would spiral *around* the magnetic field lines—resulting in circularly polarized emission!

It was an elegant way to rescue the ''icy moonlet model'' . . .. until it slowly became apparent that it wouldn't work.

Another member of Warwick's PRA Team, Dr. Joseph Romig, calculated the degree of spin required to produce the magnetic field implied by the polarization: about ten times the Earth's magnetic field. And discovered that the required rotation of the moonlet would result in the literal break-up of the object, from centrifugal forces generated by the rapid spin.

It was beginning to look like moonlets—''accreting or spinning''—weren't the answer.

The primary problem was the literal inability to see the object, or even the surrounding region where the radio waves were being—somehow—emitted. Even a moonlet several miles across, trapped in the maze of detail making up the central ring of Saturn, would be invisible to VOYAGER's television cameras. The reason that Warwick and his team knew this is because they looked . . . or they had members of some of the other VOYAGER scientific teams do the looking . . . and found nothing. To quote Dr. Richard Terrile, member of the imaging team most in touch with Warwick and his search for independent confirmation of the object, ''There is no unusual activity in the region of the B-ring specified by Evans's orbit for an object at 1.8 R_s (radii of Saturn from the center of the planet). It (the region) looks exactly like the other structure of the B-ring—extremely complex. That is all.''

It was looking like the solution to this mystery would have to come in the manner of many traditional solutions in astronomy: from astronomers working at a distance, using known laws of matter and energy and how the two relate, trying to piece together processes and events occurring billions of miles beyond their physical ability to watch firsthand.

It was a little like trying to describe the details of an heirloom pocketwatch

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from the next room—by listening intently to its ticking!

The stakes were high.

Warwick and his people from the beginning realized that their "thing" could be an important clue to understanding an entire range of processes found to be occurring in the Saturn system. It was at least plausible that the presence of a strong radio emitter in the rings was tied to the means whereby Saturn emitted SKR—those kilometer-long radio emissions believed to be coming from the planet's polar regions. The fact that Saturn was radiating *modulated*—varying—energy in the SKR, despite an almost inconsequential tilt between its rotational axis and the axis of its magnetic field, was quite amazing—and quite unexplained. Perhaps the "thing" was the source of SKR modulation.

But more than this: if the phenomenon now known by many informally as "the thing" really was a moonlet forming—accreting—somehow in the contemporary ring environment, then understanding how that process works could reveal essential clues to other accretional processes—including the still-elusive mechanisms which built planets out of a condensing interstellar cloud filled with icy debris that once swirled and orbited around the newborn sun.

We could be "eavesdropping" on the moment of Creation—at least for planetary processes within the solar system.

My own involvement with this fascinating mystery began innocently enough: I was on my way to get a cup of coffee.

It was a Sunday afternoon in August 1981, the occasion of the last VOYAGER press conference for about five years—until we reach Uranus. Less than a week before, VOYAGER 2 had made a triumphant (if somewhat harrowing!) swingby of Saturn. The harrowing part had come, you will remember, from a sudden problem with the scan platform "sticking." It is the platform which aims the various instruments—like television cameras—at targets, as the spacecraft arrows past rings, satellites, and planets. For a while it had looked like VOYAGER 2 had sent us its last pictures of the Saturn system—let alone any of Uranus.

But that was over now. The platform seemed to have "fixed" itself—somewhat—and we had gathered one last time at JPL's Von Karman Press Center for a wrap-up briefing on the Last Encounter (until Uranus) and the flood of extraordinary new information VOYAGER was providing us from Saturn.

It was in this crush of reporters, science fiction writers, and network television cameras, that I spotted Jim Warwick en route to the same coffee pot. We combined forces, then rapidly retreated to a relatively quiet corner of the press room to compare notes. It had been at least nine months—the interval between the two Saturn encounters—since I'd seen him last. And I had a couple of questions over the radio emitter in the rings. . . .

You see, when I'd last left this "saga," Jim and his people hadn't known what they'd found . . . or even where! Oh, they'd realized they'd found

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a strange, "bursty" source of radio emission in the vicinity of Saturn. But other than realizing it could not be on Saturn (for those ionosphere reasons), they really didn't know anything then, during VOYAGER 1's encounter.

It was only as I sat, sipped coffee, and listened to the unfolding tale, the months of real detective work laid out in the preceding pages, that I realized that Warwick had had incredible intuition—the heart of all real science—as well as plain gall, to have stated at that first Saturn VOYAGER Encounter:

"It's in the rings."

In fact, from all indications then it was the *rings themselves* which were crackling and spitting like a cat on a rug! The real bombshell now was the revelation that there was only *one thing* revolving in the rings, apparently acting like an extremely powerful, extremely broadband emitter.

One "thing," less than thirty miles across, as Warwick and his team judged from the timing of the bursts—the millisecond "events" detected by the radio emission. But that was only an upper limit. The actual size of this mysterious object could be much smaller.

Now, as Warwick related how the various models for the source of these emissions had been tried . . . and found wanting, in one way or another . . . I found myself willingly swept into the mystery. For it was hard to hear the tale, especially for a reader of this magazine, and not project in one's imagination what was lurking there at Saturn.

It's a long drive, at least 400 miles, north from Pasadena to San Francisco. It was late at night, up that almost deserted double lane of asphalt known to us in California as "America's Most Boring Road" (Interstate 5, north of Bakersfield), that the idea came to me.

It was so fascinating, so—yes — bizarre, that I almost drove off the road in my excitement.

"What's wrong!" My friend and associate, Heléne Knox, woke up with a start. She later described my expression as, "Almost transfixed. Staring straight out through the windshield like you'd seen an accident . . . "

"I think I've got it," I said, when finally I could say something. "Warwick's discovered a black hole."

If there is one phenomenon or object which has been more sought after (other than, perhaps, the Holy Grail) I can't think of it offhand. Black holes have been discussed on the pages of almost every scientific journal and popular account of science, dozens of television shows, even the front page of *The New York Times*, for the past ten years.

I agree totally with Phillip Morrison, the MIT physicist, when he said, "If they'd been called anything other than 'black holes,' with all those deep psychological connotations and brooding overtones, their proposed existence would have passed without a ripple. If, for instance, they'd been simply referred to as 'Schwarzchild Singularities—Class I.' "

Morrison, you see, doesn't believe in the existence of black holes—or Schwarzchild Singularities (Class I)!

Due to the brilliantly successful effort in finding a term which would gain in-

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stant recognition on the part of John Wheeler (the Princeton physicist who coined the term in 1971), black holes have occupied a reasonable share of popular and astronomical attention . . . without the confirmed discovery of even one (the much-touted case of Cygnus X-1 notwithstanding). Though a lot of suspicious-looking objects have turned up across the universe in the last decade or so of looking, including energetic cores of galaxies and quasars which now are glibly "explained" as due to massive black holes, the fact is we don't have one good example of this most phenomenal of objects.

Which would make tripping over one virtually in our own back yard such an incredible discovery.

In case you've missed all the hoopla, a "black hole" (or Schwarzchild Singularity) is simply a "pucker in the dark," a literal warp in "space-time" (to use Einstein's term for the fabric of reality). In such a region, the gravitational attraction is supposed (according to the math) to go to Infinity—if you get close enough. In calculus such a condition is known as a "singularity," ergo the other designation for a black hole.

In real terms, black holes are presumed to occur when a massive star—after doing all kinds of things to shed its excess mass, including blowing up as a supernova (!)—collapses in upon itself. With no more internal sources of energy to resist its own overwhelming gravitational attraction, the star catastrophically falls in . . . to the dimensions of a point . . . and beyond.

Heléne Knox put it thus:

In alien time,
or non-time,
your righteous anger
fades away
into a geometrical point,
which is an idea
not a dot.

The idea of your anger,
as it shrinks in size,
grows in weight,
in mass,
in density,
until it is invisible,
but warps space and time.

Your anger eats light.

Finally there are no suns left
and darkness itself
becomes too heavy
to support life.

Latent in this metaphorical description is the even more extraordinary concept that *anything* could become a black hole—provided it was smashed inward with sufficient energy and force.

In the "real universe," of course, only stars now seem to have this "singular" ability. But in 1971 another genius, Stephen Hawking, amazed the scientific community with a set of calculations providing for "mini-holes" —singularities with exactly the same gravitational effects, "event horizons" beyond which you would "fall in," etc., but with dimensions and masses far smaller than whole stars.

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Hawking called them "primordial black holes" (PBHs).

According to this English physicist, whom many consider the heir-apparent to Einstein, conditions in the first instants of the Universe amid the chaos and turbulence of the so-called Big Bang were sufficiently intense to compress ordinary matter to the point where it collapsed—

Into an entire range of primordial black holes.

The masses for these exotic objects were presumed to go from "grains of sand" to objects with the mass of moons . . . to that of planets. Even star-massed primordial black holes were calculated to have formed, according to Hawking's calculations, *if* "small" fluctuations in the density and pressure of the trillion-degree primordial hydrogen occurred in the first few billionths of a second after the Explosion.

In 1974 Hawking made his second big discovery: that black holes also share in the apparently inescapable quantum nature of the universe. He found that even black holes—those "sinks" which were supposed to eat all energy and light—weren't completely "black," but somewhat gray. They evaporated over time, depending only on their initial mass. The smaller ones went first.

It was in this way that Hawking, having "created" them just three years before, banished all those smaller holes—the ones with the mass of "mere" mountains, telephone directories, and Volkswagens—and with them a lot of good science fiction stories. Larry Niven's "The Hole Man," which appeared in these pages in 1973, was one of the first to go—because the mass of the black hole central to the story was too small to exist in the current universe!

(Jerry Pournelle continues to mutter that he also had a zinger of a story based on this smashing idea of "mini-holes." Apparently Niven beat him to publication . . . and thereby won a Hugo. But Pournelle insists he had the last laugh. He published in his column [in another magazine], before any of the journals had it, Hawking's second discovery—the irritating tendency of black holes to evaporate. Which destroyed the basis for Niven's original story, and that of other stories, articles, speculations, etc., using "typewriter-massed" PBHs as the jumping-off point. As I said, a lot of good science fiction . . . gone the way of Mercury's synchronous rotation, nights by the canals on Mars, and farming on radiation-free Ganymede. . . .)

But that still left all those other PBHs—those with masses above that of a smallish asteroid—wandering around the universe.

And it was one of *those* that I was firmly coming to believe was somehow trapped in Saturn's rings!

It took about a week for me to run down enough information on Hawking's calculations, the amount of energy a PBH above the "minimum mass" might radiate . . . and to get up courage enough to call Warwick. When I finally did, to my moderate surprise (and great relief) he listened very closely, then invited me to Boulder, Colorado, to discuss the possibilities.

And so a few months later, exactly one year after VOYAGER 1's detection

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of an extraordinary "something" in the rings, I found myself entering the small research firm Radiophysics, Inc., which is Warwick's Boulder company contracted to NASA to conduct the PRA experiment aboard VOYAGER.

I was about to plunge into the ever-deepening mystery which surrounds the SED . . . in hopes of finding that black hole.

The greatest problem for the Warwick team, in terms of gaining recognition from members of VOYAGER's ten other scientific teams that they had, in fact, found something . . . interesting (if not startling), was the simple lack of confirmation. No other VOYAGER investigation showed any demonstrable effects from something orbiting at 1.8 Saturn radii—with the possible exception of a second radio experiment aboard the spacecraft, the so-called Plasma Wave Science receiver.

Tuned to the wave band below even Warwick's lowest sensitivity (below 20 kilohertz to about 10 hertz), this PWS equipment also had recorded a series of impulsive bursts during VOYAGER 1's encounter with Saturn. The only problem was that the principal investigator for that instrument, Dr. Fred Scarf, continued to insist his signals were nothing more than interference!

It was in this atmosphere that I arrived in Warwick's office . . . and found what amounted to a state of jubilation.

Doc Evans's persistence had paid off. Through sheer determination (and some artful persuasion) Evans had convinced another VOYAGER experiment to provide him with their data. And when he looked—there, from an independent source, was striking evidence of something very strange orbiting in the middle of the densest ring of Saturn!

In a way it was even better than having access to the PWS radio data, for this information came from a truly independent source—a stellar occultation.

For about two and a half hours on the night of August 25, 1981, as VOYAGER 2 fell toward Saturn, an instrument aboard the spacecraft called a "photopolarimeter," or PPS, watched the flickerings of a bright star—Delta Scorpii—as the star appeared to drift behind the rings and planet. By monitoring the way the light intensity varied, up and down, as the thousands in separate ringlets and gaplets passed across the star in the PPS field of view, the team in charge of this experiment hoped to multiply a thousandfold our knowledge of the fine structure of the rings.

In what I have termed "VOYAGER's most elegent experiment, comparable to extremely simple techniques used by Michelson and Morely to measure something as fundamental as the speed of light," this powerful technique recorded literally millions of separate features in the rings that night, resolving individual ringlets or gaps down to the size of a city block (!), far smaller than the best television images.

What Evans persuaded the PPS team to do, through the generosity of Dr. Charles Hord, Deputy PPS Team Leader (who, fortuitously, is also based in Boulder, at the University of Colorado), was provide data to the PRA team on the crucial section of the rings. Then Evans himself laboriously matched the

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two completely different sets of data, looking for anything unusual at 1.8 R_s.

When these two strikingly different sets of VOYAGER information were overlapped, voila! *there* was a momentary "spike" of starlight—three side-by-side data points—indicating something suspicious at precisely 1.8 R_s.

Evans calculated the statistical probabilities (as he has a tendency to do at the drop of an eyelid) that these three data points were due to chance—some "hiccup" of the instrument that night. There was over a 10^{18}-to-1 probability *against* three side-by-side malfunctions of the instrument. The gap, indicated by the slice of starlight leaking through, was therefore real.

That extremely narrow gap—less than a football field in width and the *only one* for over three thousand miles across this region of the otherwise impenetrable B-ring—was, incredibly, *exactly* where Doc's controversial statistical analysis had predicted "something" should exist.

In truth, an astounding incident of confirmation by independent data!

So something really was "alive" in the central ring of Saturn, something capable of intense radio emission and able, somehow, to clear a gap the width of an average stadium—in a section of the rings as broad as the continental United States.

Such a gap theoretically should not exist, according to all previous studies of ring dynamics. It wasn't merely some kind of "traveling density wave" (as the suspicion was growing that the other complexity seen in the B-ring might just be); it was clearly a very narrow region being cleared—somehow—by something orbiting the planet Saturn. There was still not the foggiest idea of what that "something" was, but it was now quite clearly there—

—as a delighted James Warwick, "Doc" Evans, and Joe Romig kept repeating throughout the morning, savoring the moment of true discovery—as if they themselves didn't quite believe they'd stumbled across something really strange going on at Saturn.

But as I was soon to learn, things were to get much stranger.

When we came down a bit from this delicious "high," which was definitely infectious, the team proceeded to inform me of the results of their analysis of the VOYAGER 2 PRA data, taken in the same time period (within a few days) as the preceding PPS stellar occultation data.

Everything had changed.

VOYAGER 2 recorded *less than ten percent* of the number of "events" recorded by the first spacecraft a mere nine months before. Furthermore, the polarization indicating that the source possessed a magnetic field had simply vanished. There was no consistent polarization to the VOYAGER 2 signal, despite a geometry (relative to the rings) which should have duplicated that of VOYAGER 1. And, speaking of geometry, when VOYAGER 1 had flown far beneath the rings, before being thrown up and away from the planet, to leave once again on the rings' sunlit side, it had recorded a mysterious four hours when the SED signal was *not* broadband—but slowly slid from higher

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to lower frequencies across the range of the PRA receiver.

VOYAGER 2's encounter of the planet, coming in above the rings on the planet's sunlit side and leaving by slicing downward through the ringplane on the planet's nightside, had been expected to see a similar frequency-dependent relationship—if the geometry of the source in the rings, able to "see" the spacecraft from a narrow gap, was somehow involved. But VOYAGER 2 had seen no such frequency-dependence over time at its encounter. One more parameter of whatever this thing was had changed.

About the only two things which remained constant between the two encounters were the *power* of each individual "burst" and the orbital period. Evans's statistical analysis indicated a revolution period of 10 hours, 11 minutes, plus or minus that standard deviation of five minutes. From this it was concluded that the orbit was the same, although the difference of that minute might be real. With this peculiar "thing" there was no way of absolutely knowing!

What really shook everybody up was that drop of a factor of ten in the number of individual events in the mere nine months between the two encounters. From all the evidence it looked as if the "thing" was dying!

That was statistically absurd.

The odds—against a truly ancient source of radiation in the rings persisting across cosmic time, possibly since the formation of the planet billions of years ago, only to be rapidly vanishing just as we arrived—were overwhelming. It was the same kind of reasoning used to quantify the statistics of finding another civilization nearby with just our level of technology: the mathematical coincidence would be too great, in any reasonable estimate of the lifetime of the universe! There had to be another explanation.

The likeliest was that something in the ring *environment* had changed, something which brought more or less "ringstuff" into contact with whatever was the source. Rich Terrile, not a month before, had showed me splendid photographs of moving waves of particles occurring in the outer regions of the B-ring. These "density waves" were thought to be triggered by tidal resonance with Mimas, Saturn's largest inner moon. The photographs demonstrated strikingly that features in the rings could change—and on a scale of mere hours. It was not unreasonable to assume that similar (though smaller) density variations also were occurring in the inner sections of the ring, including the immediate vicinity of whatever was the "thing." Unfortunately, when Terrile looked specifically for changes in this region, he found nothing—which may simply mean the waves are far too small to show up at television resolution.

But if this was the explanation for that dramatic drop in the number of SED events between the two encounters, then it also (thankfully!) excluded at least one of the numerous new models which had sprung up in the wake of the demise of the "accreting moonlet" theory: that the object is a *magnetic monopole* trapped within the rings.

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This was Jim Warwick's own "far-out" idea (to compete, one suspected, with my own equally extraordinary suggestion—that we're dealing with a primordial black hole).

Magnetic monopoles are predicted by certain obscure aspects of sub-atomic theory. They are what the name implies: elementary particles imbued with some very special properties, among these an extraordinarily high "rest mass"—at least several million times the proton (!)—and a single "pole" of magnetism, either "north" or "south."

Warwick apparently had been doing what I'd done, after the evidence failed to bear out the "grandaddy moonlet" concept: searched the literature for other strange objects which might explain the high-powered radio emission. Magnetic monopoles seemed at first a plausible (if not probable) substitution.

But now Warwick ranks such a prospect as being rather remote. There are two primary reasons: the inherent instability of such a particle, trapped in the rings; and the difficulty in identifying a mechanism whereby the number of "events" could drop by that factor of ten recorded by VOYAGER 2, while the power of each individual event remained the same.

The idea initially favored, that cosmic rays were being attracted to the monopole, thereby producing the emission, can't support the changes VOYAGER observed. As to the long-term prospects for such a unique entity remaining in the rings for millions or billions of years, that too seemed difficult to swallow. Warwick had proposed that such a particle was trapped within one of the trillions of other snowballs making up the rings. But random factors, such as mutual collisions or the literal vaporization of the snowball from the prodigious energies released with every cosmic ray acceleration, would in a twinkling liberate the monopole—which would immediately, gleefully, fly toward Saturn's opposite magnetic pole . . .

To bury itself forever in the center of the planet!

The problem, then, came back to sheer statistics: what were the odds against our arriving before any of that happened? The answer: overwhelming.

Which brought us back to abnormal "normal" objects . . . and black holes.

It was now that I got a chance to lay out my own ideas regarding this extraordinary object.

First, there was the small matter of the energy density. If the power that VOYAGER recorded—10^8 watts—were being uniformly generated throughout the volume of the object (a highly unlikely possibility, in any case) then one could perform some simple calculations regarding the amount of power being dissipated in that volume. One could begin with an assumption that the efficiencies—energy into radio emission—were the usual one or two percent typical of other astrophysical processes.

If that was the case, then the total energy being somehow concentrated in this one tiny region of the rings was in excess of ten *gigawatts*—enough to power a city like Los Angeles or New York!

Now take the case of bandwidth. It was assumed from the VOYAGER PRA

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experiment that the emission stretched from something below 20 kilohertz (20 thousand cycles per second) to 100 megahertz (100 million cycles) in the radio regime. But there was growing suspicion that the emission could, in fact, extend across a much broader range of wavelengths—up to possibly a *billion* hertz (a billion cycles per second) and more. If that were true, multiply the total power for the "thing" by another factor of ten—to 100 billion watts.

We're now within striking range of the total electrical consumption of the United States!

All right, let's consider volume.

Warwick's original idea—that this object was a single, 30-mile-or-so moonlet accreting in the B-ring—was merely an upper limit on the object's size, as determined by the timing of the individual "strokes" of emission. Lightspeed defined the radius of the radio emission. If one averaged out that power through the volume represented by a sphere 30 miles across, power density came out to several thousand watts per cubic mile. But that wasn't the true picture. Electrical charging takes place on the *surface* of an object, so it is really surface area which is important for this model. The actual discharges, therefore, could be envisioned as taking place within a much thinner "layer" on the surface of this 30-mile-wide sphere — leading to truly extraordinary energy densities.

But now, for a variety of reasons, the simple "accreting moonlet model" was kaput; for one thing, how could one fit a moon several miles across into a gap the width of Yankee Stadium?! It was strikingly, beautifully apparent from the discovery of that small gap in the photopolarimeter experiment that whatever we were dealing with was *small*. And that, of course, increased the basic mystery: how could that much energy be released, let alone generated, in such a tiny volume?

Let's take a moment for a couple of comparisons.

At Jupiter VOYAGER also discovered some extremely energetic objects and phenomenon. Perhaps the best example is the highly charged and constantly dissipating "Io Torus," a donut of high-temperature material approximately ringing Jupiter at the distance of its fascinating inner satellite, Io.

The Io Torus is now known to be composed of atoms ejected from volcanos on Io. The material, thereafter, is heated and ionized by interaction with Jupiter's magnetic field, which traps the material for a while within an inner-tube-shaped region located some quarter of a million miles above the cloud tops of Jupiter itself.

If one takes the trouble to compute the *volume* of that torus—the sheer number of cubic miles represented by a donut something like a million miles across (when you've accounted for its own "fatness" and distance from the center of the planet)—you get about 10^{14} cubic miles. Io is constantly creating one hundred *trillion* cubic miles of highly energetic plasma.

VOYAGER's various experiments —both radio and ultra violet—measured the amount of power being radiated by this torus. That figure is around 10^{12}—a trillion watts (10^{12} joules/sec), roughly

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equivalent to the power generation of North America. Adjusting for the inefficiencies in conversion alluded to before, that means something like 10^{14} watts are being dissipated in the torus in random kinetic energy of atomic motion.

Dividing one number by the other, that leaves us with a rough estimate of the *energy density* for the Io Torus: about 1 joule per cubic mile!

It can be seen, therefore, that though the total power figure for Jupiter is strikingly impressive, it's being generated through a volume of material so huge that the contribution of any individual unit of material—in this case, the ionized atoms liberated from Io—is trivial.

This is in striking, bewildering contrast to what's happening within the ring at Saturn. If, for the sake of more simplicity, we assume that whatever generates this power is confined within the three-hundred-foot gap within the B-ring, then the energy density for the "thing" goes up geometrically as the inverse *cube* of the radius—the ratio between a sphere 30 miles (168,400 ft.) across and another a mere three hundred feet.

A factor of eight hundred *million!*

In this simple manner it was easy to demonstrate that the *minimum* energy density of whatever's causing that narrow "canyon" in the B-ring is on the order of a *trillion joules per cubic mile*—roughly the energy radiated by the entire Io Torus—

—compressed into a volume equivalent to Yankee stadium!

For those of us whose first impressions were awe and sheer amazement at the Jovian phenomenon—that one planet could casually dissipate such energy (as in the Io Torus) on such a prodigious scale—it was now becoming clear that what was taking place at Saturn, by comparison, was just bizarre.

For, despite the previously calculated extraordinary energy compression of the source of SED into a volume trivial on the scale of any known planetary phenomena, no other VOYAGER experiment (with the exception of the PPS occultation detection of "the gap") saw *anything* unusual within the rings.

CONTINUED IN NEXT ISSUE

● It might well be the case that the universe has produced and will continue to produce countless millions of...histories analogous to human history....To attempt to draw ultimate conclusions about God and the universe from a few episodes of the history which has been enacted on this planet would seem to be a most hazardous if not impossible proceeding.

John MacQuarrie

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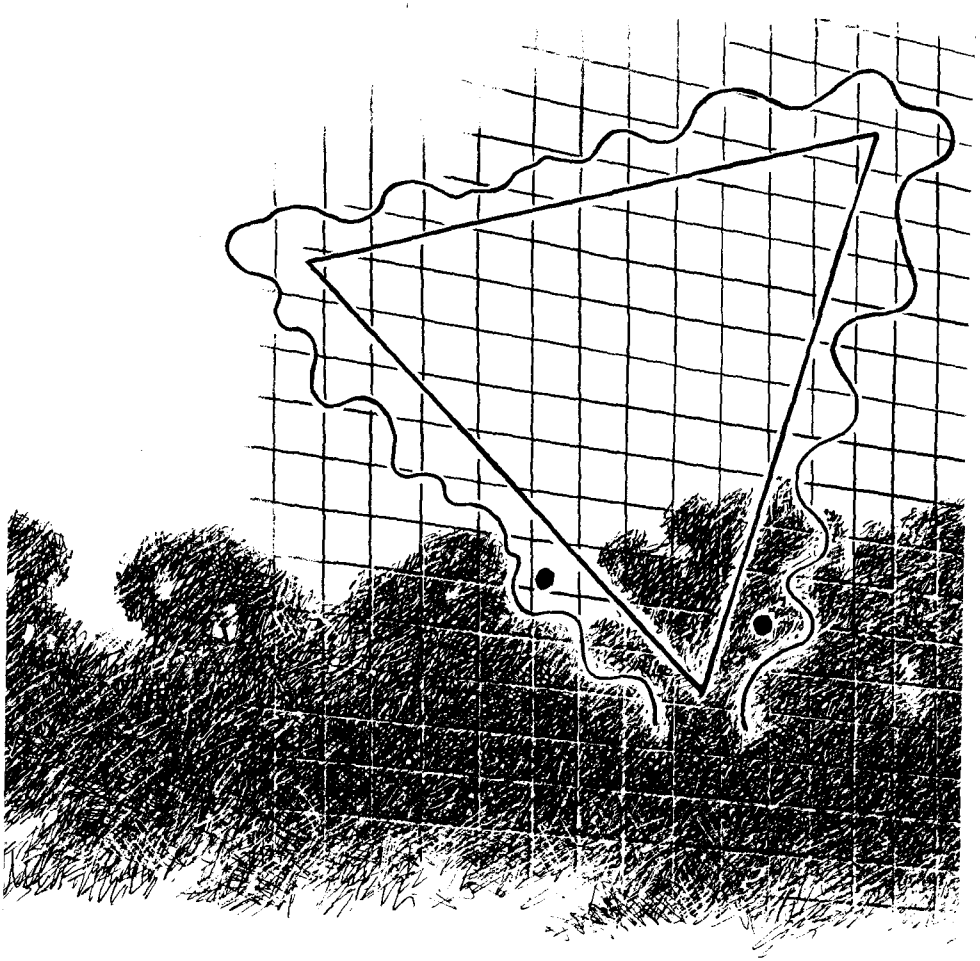

Ray Brown

BIG TRUTHS

Naturally, alien beings will see things differently. Literally, even...

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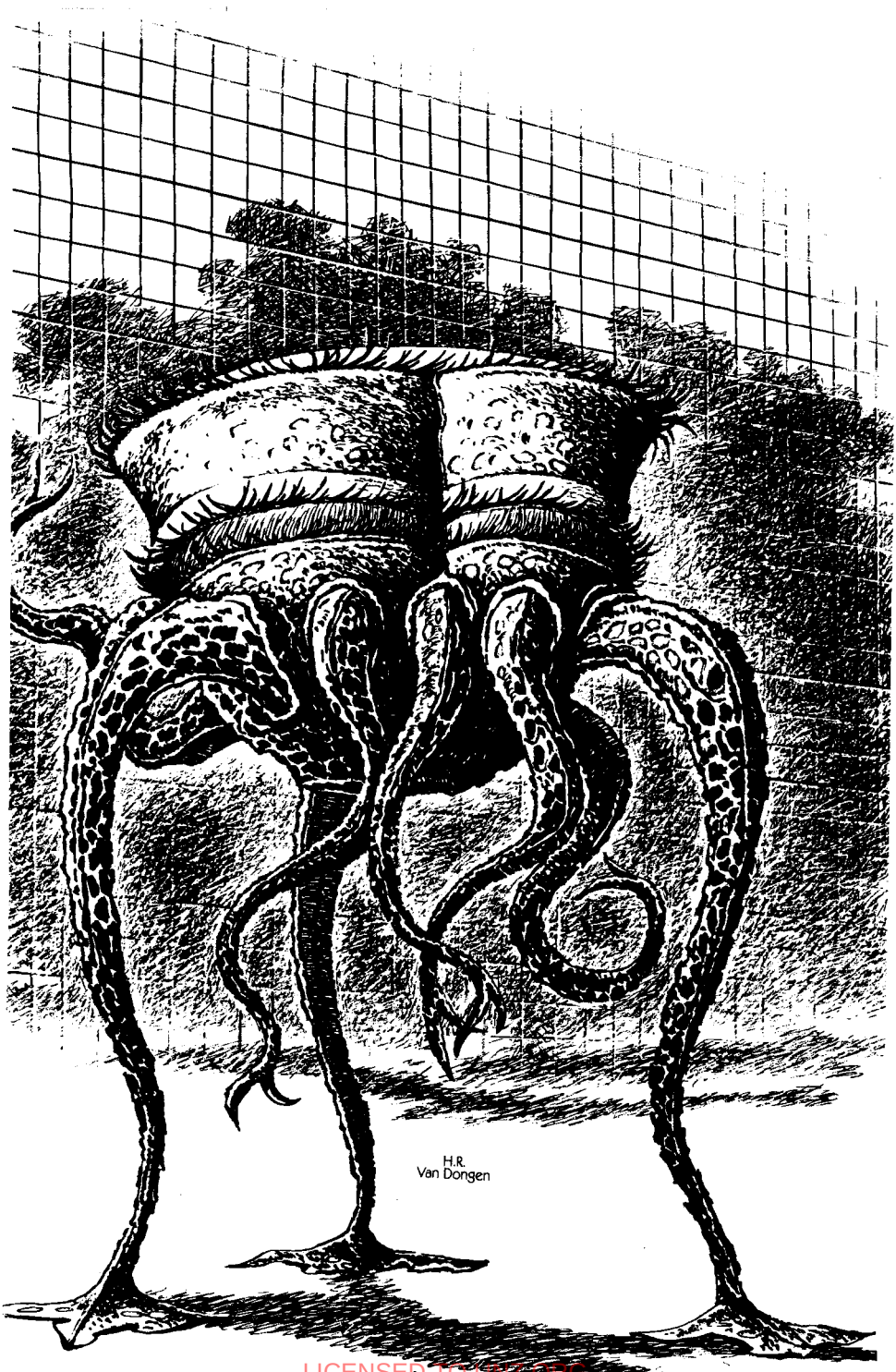

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Joe Stacey, the optician, felt bored and edgy. Since it was more fun than watching the Gibber-Twitches trying to gnaw through the glass brick window—an amusement that grew stale after the third day—he took his break in Bludge's office and watched him typing on the office console with fumbling fat fingers.

"TRANSMIT 3/12/2439/0021441 BIG TRUTHS. DWIGHT BLUDGE 614874201."

"DONE," the screen flashed back.

Stacey had only been on this planet with Bludge for a week, but already he was beginning to have doubts about him. Why was *Big Truths* so compelling when there was a chance for conversation?

"RECORD."

"DONE. TRANSFER 7 GM AG ACCT 0021441."

Stacey congratulated himself on having the foresight to bring a sack lunch. He dug in.

"RETRIEVE."

"TRANSFER 7 GM AG ACCT 0021441."

"Do you have to read over my shoulder?" Bludge asked aloud.

"Sorry," said Stacey, continuing to read over his shoulder.

"RETRIEVE," Bludge typed again.

"FORK OVER THE SILVER OR GET WIPED, BUDDY!"

"Goddam uppity machines are running our goddam lives," Bludge muttered, typing out the authorization.

"I should have told you," Stacey mumbled through a mouthful of carrot. "A repairman from the Central Bank dropped by this morning. No more freebies."

"I figured that out," Bludge growled.

They both looked back at the screen. The dun had been replaced with the first page of the magazine:

BIG TRUTHS

EY 3/12/2439 *LY 246/11,303*

"Bringing the science of the galaxy to the galaxy"

TINY OUTSIDE ATOM-SPECK THINKING MOVEMENT BETTER FOR THROUGH-SPACE THINKING MOVEMENT THAN MOLECULE THINKING MOVEMENT

Bludge seemed fascinated by the article. All Stacey could get out of it was that species with neurons that transmitted electrically were supposed to have "better" ESP ability than those that did the job with chemical helpers like acetylcholine. He squinted at a particularly involuted section:

Example: Terran slow through-space thinking is off-again on-again and trickles, showing their slow, weak molecule thinking movement.

Like a lot of Lalandan scientific thought, the evidence and the thing to be demonstrated seemed hopelessly intertwined.

"Do you understand that?" Stacey asked, pointing.

"Sure," said Bludge. "It means that humans don't have very good ESP."

"True, but that's not exactly what I meant. How is this Lalandan proving anything?"

"Oh! You can't expect it to make good sense, you know. Human minds just don't work like Lalandan minds—nor like the minds of any of the other races, for that matter. You simply have to trust that the Lalandan review board knows what it's doing, and read for the news value."

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"So even though you don't understand it, you believe it."

"What else can I do?" Bludge asked, shrugging his bearish shoulders. "The one thing I can fully appreciate in Lalandan science is its success. They've had thirty papers published in the last decade!"

"Huh?"

"In *Big Truths*, I mean."

"That's success?"

"OK, if you want to judge by technology—they perfected cheap transmutation just last year. When that spreads through Civilized Space, it's really going to change things. But you're right, I'm actually judging by the number of papers they've had published in *Big Truths*."

"But half of them are gobbledygook!"

"The amazing thing is that a Terran can read and comprehend any of it. It just goes to show the skill of their translators. After all, at last count there were better than six thousand intelligent races in Civilized Space, according to *Big Truths* . . . "

"Civilized Space being defined as any planet with subscribers to the magazine?"

"Maybe, but do you know of any other scientific journal with even a quarter the circulation? I think their definition is a good one. Do you ever read *Promo* magazine?"

"No."

"You should. I remember Dad used to tell me that. 'Dwight,' he'd say, 'you can always trust *Promo*.' I never forgot that." Bludge nodded solemnly. "Anyway, *Promo* described *Big Truths* as 'the conductor of the galaxy's scientific orchestra.' "

"They said that, huh?"

"That's right. And they also said, 'no one who even pretends to be an intellectual today can afford not to subscribe.' "

"So how come you buy your copies one at a time?"

"I'm not pretending."

Stacey grinned—partly with relief. He'd begun to suspect Bludge of being entirely humorless. Relaxing a little, he decided to indulge his own peculiar, Staceyish brand of fun.

"By the way," he said, "you should keep in mind that it's mostly luck that we're able to read and understand as much as we do of *Big Truths*."

"What do you mean?"

"Didn't you know? When they started the magazine, two centuries ago, they decided to publish in English because humans were so notoriously rotten at learning the languages of other races."

"I never heard . . . " Bludge squinted at Stacey. "Are you putting me on?"

"I thought surely a fan as ardent as you would have been familiar with the magazine's history," Stacey said, still grinning—his bony face making the death's-head that kept him from smiling at mirrors. "It's too bad the problems of interspecies translation are still so overwhelming that the papers end up reading like scientific baby-talk."

Bludge's face warped into something hard, pinched, and nasty. "I've heard enough of that," he said. "*Big Truths* is the only real scientific link between six thousand cultures. It's the best thing galactic science has going for it, and any scientist worth his salt admits it."

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Stacey thought fast, reevaluating his position. Bludge was the optometrist, after all, ergo, his boss. He barely knew Bludge. Maybe his joke about not pretending to be an intellectual hadn't been a joke at all. Maybe he took his role as optometrist-scientist, digging big truths out of *Big Truths,* completely seriously. And he was right, at least, about the weight *Big Truths* swung in the galaxy. It was probably best to just get off the subject.

"So," Stacey said, "it must be the scientific aspects of optometry that fascinate you."

Bludge relaxed, smiled, nodded. "That's why I'm here on Hoon. In fact, when I started college, I set out to be a mathematician."

"What made you switch to optometry?"

"My professors were fools."

Stacey flinched. He *had* been serious!

"I know what you're thinking," Bludge accused. "That's a pretty common excuse for failure. But you wait and see. I'll make them sit up and take notice. There's a lot to be done in optometry, too, and the Hoon are just the people to do it to . . . uh, maybe I should rephrase that. . . ."

Stacey smiled weakly. "I guess any original work, however minor, would be good for us, status-wise. Earth's science seems to be petering out, lately."

Bludge snorted. "Humans haven't had but one article in *Big Truths* in the past twenty years. It's a scandal. Especially considering the language advantage."

"But there are other journals," said Stacey, still urging Bludge to dismount his hobbyhorse. "Many of them are very distinguished."

"You publish in other journals to keep your hand in," Bludge said, waving his airily. "But if you publish in *Big Truths,* your reputation is made."

That was when Stacey first suspected that Bludge might be a Problem.

Stacey waited for the afternoon testing to begin, sitting at a desk near the curved wall of the Exam Room—an Exam Room unlike any other, built under the humans' direction by a team of swift Hoon in less than a day. It resembled a planetarium—but this planetarium worked backwards. Things were projected from a hemisphere of jackleg equipment at the Hoon, who stood where the projector would be.

"Hoon?" the Hoon said, plaintively.

Stacey studied it, amazed for the hundredth time. Even in the context of six thousand races, a Hoon was odd: a gentle, intelligent vegetarian on an exceptionally nasty planet.

The three humans—Stacey, Bludge, and Lansing—never went out. They were entirely walled in, for their own protection, from Earthling House at one end through the row of offices and supply rooms to the Exam Room at the other. Nobody minded. They'd got a panorama when they landed, and they could view the Gibber-Twitches distorted through the glass bricks. The little they saw was enough. Hoon was a jungle in every sense of the word—a tangled green place full of mobile nightmares with sharp teeth and insatiable appetites.

Yet out of this came the peaceful Hoon.

Supported in mid-air by three of the

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eight muscular tentacles branching from its middle, its torso hung, looking like a conga drum complete with a drumhead which acted as both eardrum and vocal cord. When a Hoon talked it couldn't hear. In primitive times it had used the tympanum to sound a booming "HOON" to frighten away the more gullible carnivores. Only the top third of the conga was devoted to breathing and doing tricks with the air; the rest was filled with the usual run of organs—slop Stacey didn't like to think about, connected to a single opening near the bottom for intake and outflow.

The only other uncommon organ was the Hoonish eye, about fifteen centimeters above the ring of tentacles. It was a lidded, shiny black band that ran completely around the torso. Hoon had 360° vision.

Theoretically.

"I can see yet?" the Hoon asked, rattling and whispering. Stacey could barely understand it. Though it made their valves and tympanum sore, it was at least possible for a Hoon to speak English, and so they were stuck. Only the Hoon could understand Hoonish. To everyone else, the language seemed to have only one word.

"That's what you're supposed to be telling me," Bludge said with a sigh. "Are you sure this one is supposed to be from the supply of normals, Al?"

"Excellent vision, they *tell* me," answered Lansing, the ophthalmologist. "I wouldn't know."

Bludge shrugged and pulled a switch on the wall. A spot of light pulsed in curves around the room. "Follow that with your tentacle," he said. "Point it out. I'm going to vary the speed and amplitude."

The Hoon tried to oblige. It started out well enough, its tentacle weaving up, down, and around with the light, but after a few turns it began to pull farther and farther ahead. Finally, as it was spinning halfway around the room ahead of the pulse, all five unused tentacles flew up, waving frantically.

"I can see yet!" the Hoon proclaimed proudly.

Bludge groaned with disgust and slapped the switch off.

"I don't understand it," he said. "I got the idea for this test from a source specifically cited in *Big Truths*."

Stacey kept his mouth shut. After a minute, Bludge continued.

"It still looks to me like every member of this race has some sort of superastigmatism. The ones they say have bad vision just aren't adjusted to it as well. We've got to keep digging for their basic perceptive geometry."

"Why don't we just find out how the hell their eye works?" Stacey asked.

"I keep telling you, we don't have to. And if we did we might just be wasting time. Perception goes beyond the mere construction of an eye—we can do better using what we do know. We know it uses light, and we know how light works already. And by measuring their reactions . . . "

"Al," Stacey cried, "you're an ophthalmologist. *You* tell him!"

Lansing, an old man who liked behaving like one, was sitting in a folding chair away from the battle, pretending to doze. He raised his lids slowly, as if the effort of realigning his wrinkles took a lot out of him.

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"Don't ask me," he said. "I don't understand your arguments. All I know is how to set the dials on the Doc to cut up eyes and fix them. If the Hoon hadn't insisted on having a representative of all three branches, I wouldn't even be here."

Stacey turned to the Hoon. "Why did you want all three specialties?" he asked. "You wanted an ophthalmologist because you don't understand how your eye works, right?"

"We understand," the Hoon rattled. "Eyes work with bleached-by-light to make nervous electrics. But only five of all the Races who breathe our air have separate sciences of seeing apart from other health-knowing. Earth is the only one of the five with three specialties, and five and three is eight."

There was an air, somehow, of finality in the Hoon's addition. That settled it.

Bludge grinned at Stacey and walked along the curve of the wall to another bank of dials and switches. As he played them the room darkened and a holoprojection of a green triangle floated across the room, stopping about a half-meter from the Hoon's eye.

"Hoon?" Bludge asked, turning to the Hoon, "you understand half a line?"

"Yes."

"The outsides of the green thing are three lines."

Two red dots flashed on two sides of the triangle.

"And where those dots are are halves of lines."

A slim black snake writhed about the triangle. The Hoon flinched.

"When this black thing becomes a straight line joining the dots, tell me the word 'stop.' Do you understand all that I have said?"

"Yes."

Bludge muttered "Thank God!" and Stacey made a mark on his checklist. This made the sixty-first Hoon they'd tried this test on, and the nineteenth that understood it. The snake began straightening and curving itself, moving up and down the triangle.

When the Hoon said "Stop," the black line, now slightly curved, rested away from the red dots, almost at the tip of the triangle.

The room brightened and the figure disappeared.

"Out of nineteen," Stacey announced, "not one has even come close. There's been no consistency to their misses. The one who missed by the least was supposed to have bad eyesight."

"I don't care," said Bludge. "There's a pattern there, somewhere. All we have to do is find it. Let's try circle completion next."

"Look," Stacey said, exasperated, "even on Earth nothing was proven with those geometric tests. Some people with 20-20 vision saw a non-hyperbolic curve as the midline. Some saw something very close to Euclidean."

"But the vast majority *did* see a hyperbolic midline. Anyway, you're missing the point . . . "

"OK, boys," Lansing said. "You've finally aroused my curiosity. What the hell are you talking about?"

"Non-Euclidean geometry."

"Oh." Lansing's face fell. "I studied Euclid in my youth, but nothing else."

"I can easily give you an idea of how it works," Bludge said. "The classic classroom example uses a sphere. The

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shortest distance between two points on the surface of a sphere is a curve."

"That's supposed to be non-Euclidean?"

"Hmm." Bludge frowned. "I suppose it isn't, really. But then you're asked to imagine that space itself is like the surface of a sphere."

"Why?"

"Never mind. *Our* concern with geometry lies in its relation to the eye. Lobachevskian geometry, for instance, assumes that space is hyperbolically curved. Most humans—even those like you, who've been trained in Euclid and nothing else—*see* in that geometry. This was established 'way back in the twentieth century with a triangle test a lot like the one I just used."

"So how does that help us with the Hoon?" Lansing asked. "Haven't we already proved they don't see things the way we do?"

"The point of these tests is to establish what geometry they *do* see in. They've been applied to other races with good results. It was through them that we found out the Great Plains Rats of Al Nair V really do see in Euclidean space. And other races have been shown to see in other non-Euclidean patterns. When we try to correct the Hoon's vision, we want to be helping them to see what *they* want to see, after all."

"I think I see," Lansing said.

Stacey ground his teeth. It sounded so reasonable. It was too bad about Lansing—since he was the only other human on the planet, it made you yearn to win him over to your side, and that didn't seem likely. Bludge was trying to fix something without knowing how it worked, but Bludge could answer that objection, quite reasonably, by pointing out that half the history of medicine consisted of doctors fixing things they didn't understand.

Intuition told him that the situation on Hoon was different, but intuition got you nowhere in a debate. *How* was it different? In desperation, he tried the Hoon again.

"Hoon," he said, "you seem much better at English than most of your race. Why don't you try to tell us what your own understanding of the problem is?"

"Thanks for complimentary," it said. "I teach English at the Great School. But I don't know why. Why?"

"No, no. I want you to tell us why."

"We are circle-sighted," it said. "Not long ago, perhaps 1500 Earth Year, came missing-of-the-object. Most recover, or learn where the missing-of-the-object will be, but small ones need time, and it is dangerous when the Eaters come."

"Feh!" said Stacey.

"Say," said Bludge. "He really is exceptional! This could be the answer to our problem."

"Which problem is that?" Stacey asked.

"Amassing data. Hoon, could you help us? Could you—uh, will you translate for us?"

"I do not know 'translate.' "

"Will you tell Hoon for us what we have said in Hoonish?"

"You can not speak Hoonish."

When the Hoon finally understood he became very excited, said he was "honored eightfold," and agreed to work for free.

"This is great," Bludge said. "Now

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we can devote ourselves to the geometric tests exclusively."

One month and six hundred Hoon later they were no forwarder.

Bludge paced in the living room of Earthling House, talking it out, while Stacey and Lansing, sprawled in easy chairs, watched wearily. Lansing was beginning to have doubts too, Stacey was glad to see.

This almost made up for the fact that Bludge was getting worse. He paced a lot these days. He snapped at Stacey and Lansing. He threatened the repairman from the Central Bank with physical violence. He was developing a tic.

"Maybe it's not astigmatism," he admitted, kicking the robodog as he passed. "At least, there must be additional complicating factors."

"Fine," said Stacey. "I'll go along with that. In fact, I'd say there are so many complicating factors that these geometric tests are of no use at all."

"We know how you feel," Bludge said, slipping into aristocracy. "You've made no secret of it. But you're wrong. The Hoon are all one race, and there must be a common mode of perception."

"I'm not saying there isn't. I'm just saying we're going after it the wrong way. If we take these test results seriously, we seem to have eliminated Lobachevskian geometry, Euclidean geometry . . . "

"We know. And Riemannian geometry and all the others, including the non-human. But the Hoon aren't blind, you know. They don't bump into things . . . at least, they usually don't."

"Maybe they see by some geometry that hasn't been invented yet," Lansing suggested tartly.

Bludge stopped pacing so suddenly he almost fell over. His face blanched and a stubby finger shot overhead. "That's it!" he yelled.

"Oh, for Christ's sake . . . "

"No, I realize you were trying to demoralize me, Lansing," Bludge said, "but I think you've got the answer, all the same. I don't know why I didn't think of it myself. We've been trying to match our test results up with different geometries—different preconceived standards—and that's where we went wrong! The thing to do is to go through the results again and look for their own internal consistency!"

"There isn't any," Stacey said.

"Sure there is. Remember the circle-completion tests? A whole bunch of Hoon coped successfully with a thirteen-centimeter circle at one meter's distance. What was the percentage?"

Stacey sighed, pulled a sheaf of notes from under his chair, and thumbed through them. "Seventy percent," he said. "But they didn't get any of the other circles."

Bludge laughed. "So?" he said. "All that proves is that in this particular geometry, there are a limited number of circles." He grabbed the notes from Stacey, took a chair, and screwed his face into a look of enormous concentration.

That was when Stacey decided that Bludge was a lunatic.

Two months later, Stacey was forced to an amazing conclusion: It didn't matter whether Bludge was a lunatic or not.

And there was no doubt, now, that

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he was. Bludge had developed his new geometry into a system that was wonderfully pertinent to the Hoon's plight. They couldn't connect the two red dots in the triangle test? Very well—then lines and points *didn't* connect in the system of their vision. He laid it all out carefully and logically for Stacey and Lansing, like some mad medieval schoolman.

It was obvious, Bludge had concluded, that no prosthesis could be devised for creatures with such a mode of perception. That left only eye exercises. He went about devising a program of exercises with the same startling logic he applied to mathematics. The Exam Room was renamed the "Visual Gymnasium." Hoon were stood in the center and Bludge, Stacey, and Lansing, following Bludge's script, ran from control board to control board, throwing almost evey test they had at the Hoon while Bludge, panting, told the Hoon what to concentrate on.

"It looks like a goddam fireworks display," Lansing had said.

Stacey wasn't sure what the exercises were doing for Hoon eyes, but they made his hurt. After two months of it, he found himself racked by constant headaches. He was lying on the floor of the "gymnasium" between treatments, using an eyedropper as God intended it to be used and cursing the day he first heard of Hoon, when he noticed through his soothing tears a whole troop of Hoon weaving in.

He sat up and blinked his eyes and the white thing the lead Hoon was carrying coalesced into a highly gilted ceremonial scroll. The Hoon extended it toward Bludge.

"It is to thank you for the curing of us," the Hoon said. "The missing-of-the-object comes much less now among those you have given the eye-work to. You have given greatest wonderful in our nine hundred Earth Years of civilized. Now you will teach us how to give the eye-work, and then you will be finished here."

"What!" Stacey croaked.

The Hoon repeated it, word for word.

Stacey pushed himself off the floor, legs wobbling, and began to stumble toward Lansing. The scene, the room —the whole planet—suddenly seemed unreal to him. He felt like he was swimming through the watery air that slowed him in his dreams.

"Hoon, I thank you for this token," Bludge was saying formally. "It is good to be appreciated. I think I can begin teaching you in two weeks. First, however, I shall write a paper on my methods to gel my thoughts, that I may teach you more efficiently."

"Do you really think *Big Truths* will be interested?" Stacey gasped.

"You must think I'm very presumptuous," Bludge said. "I'm going to send it to the *Journal of Interstellar Optometry*. Say, what's the matter with you? Are you ill?"

"Yes."

"Then get out of here. Go to the couch in my office and lie down."

"Yes. Mr. Lansing, will you give me a hand?"

By the time they got to Bludge's office, Stacey was feeling near-normal again. He plopped onto the couch, glanced at a page of *Big Truths* on

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Bludge's still-lighted screen, turned to Lansing.

"I don't believe it," Lansing said.

"The Hoon themselves say they're being cured. Who are we to contradict *them?*"

"Bludge must be the luckiest bastard in the universe."

"Is it luck?" Stacey asked softly. "Maybe we're missing something."

"Of course it's luck. I might not know a lot of math, but even I can see that this latest theory of Bludge's is insane."

"I don't know. It's certainly complete and consistent—in its own way."

"My grandma," Lansing said, "had a theory that Queen Elizabeth wrote Shakespeare's plays. It was complete and consistent, too."

Stacey laughed. "You're right, of course. Bludge has been lucky. And we are missing something—after all, the Hoon are being helped in some way. How?"

"Far as I can see, he's just flashing a lot of lights at them."

"And asking them to concentrate on some, using others as distractions. Don't forget that. Can you think of anything else?"

"Not unless you buy his theories."

Stacey felt his body slump in discouragement. "Hell," he said, "it might be just one little thing in that whole light show. With Bludge in command, how will we ever find out what it is?"

"Maybe things aren't as complicated as you think. In the old days quacks used to take in suckers with machines with flashing lights. Maybe it's nothing more than that. After all, how sophisticated can the Hoon be? That Hoon with the scroll said they'd only been civilized nine hundred years."

Stacey jerked upright. "That's it!" he yelled.

"Oh, Christ," Lansing groaned. "Not you, too! I was just kidding around, Joe."

"No, I mean the part about only nine hundred years of civilization. Do you remember what our translator said when we first interviewed him? About this problem cropping up around 1500 EY? That's nine hundred years ago."

"This is beginning to sound interesting."

"And I remember something else . . . hey! I think it's falling together!"

"So tell me."

"I was thinking about our translator talking about 'nervous electrics' and it struck me—a few months ago, in this very office, I was reading an article in *Big Truths*. It was talking about the difference between creatures that need a chemical action to get through the insulation of their neurons, like us, and the creatures that do it electrically. The latter are usually pretty good at ESP."

"And you think the Hoon are like that?"

"He described rhodopsin pretty accurately—'bleached-by-light.' If he meant something else when he said 'nervous electrics,' I think he would have *said* something else."

"The missing-of-the-object," said Lansing.

"Huh?"

"I bet they're good at precognition. The translator also said they learned where the missing-of-the-object *will be*."

Stacey nodded eagerly. "And when

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he moved away from the pulsing light, he was moving ahead of it. It fits in. Suppose Hoon eyes have always been basically lousy. Before civilization it didn't matter, because they have excellent short-term precognition. All the eyes have to do is give them the direction of motion—they're to focus attention, to give the Hoon something to latch their ESP onto. There are enough nasties out there in the jungle to give them plenty of practice. But after civilization comes reading and writing and all those times when you're focusing your attention on one point in space for long periods of time. And they spend a lot of that time in buildings like this, safe from attack. So some of them get out of the habit of working their eye and their ESP together."

"So you're saying it's a sort of psychological problem."

"I don't know if that's the right word. But it's the kind of problem that exercise—*any* exercise with lots of motion involved—would help. What do you think?"

"I'm not sure. For a whole race to have ESP and not know . . . "

"It's intimately connected to the eye. They'd have no reason to think that the eye wasn't the only organ involved. Of course, that's going to make it very difficult to prove."

Lansing thought a few minutes, then shrugged. "I'm still not convinced," he said. "But you make a lot more sense than Bludge."

As if that were a cue, Bludge walked in, carrying his scroll. He made snake eyes at them, then widened them to a look of startlement.

"I don't believe it!" he said. "You're *malingering!* How could you goof off at a moment like this?"

"Actually," Lansing said, "we were discussing . . . "

"I don't want to hear it. Just get back to work. I'm tired of doing everything around here."

"That's the natural result," Stacey said carefully, "of monopolizing every aspect of the research."

Bludge laughed. "I believe you're jealous," he said. "In a way, I suppose that's understandable. I doubt that you've ever had to take back seat to a mathematical genius before."

That was when Stacey decided that Bludge was Fair Game.

The first maneuver in Stacey's campaign was to swear Lansing to silence concerning the idea that there even might be an alternative theory. The next step was to make sure the Hoon really did have all-electric nervous systems. There were simple tests for this, and they came out positive. The last step was to write the theory down in the form of a paper to be transmitted, via the tachyon link, to the editorial offices of the *Journal of Interstellar Optometry,* and to time it so that it went out about the same time as Bludge's.

This was very time-consuming, and Stacey didn't have a chance to really talk with Lansing again until it was all done. He bumped into him late one night in the kitchen of Earthling House, carrying the printout of his paper.

"Is that it?" Lansing asked, setting his coffee cup down and pointing in the general direction with a gnarled finger. "It's big!"

"That's because it's really two papers

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combined into one,'' said Stacey, taking a seat beside him. ''The first section deals with our own theory.''

''And?''

Stacey grinned. ''The second part was pure personal satisfaction. It's—how shall I describe it?—an *appreciation* of Bludge's math. Let me show you.'' He riffled through the printout, stopped suddenly, and began to read aloud:

BLUDGEAN GEOMETRY

(''ahem'') *Disregarding, for the moment, its intrinsic beauty, Bludgean geometry has no use its expositor can see save that of reflecting on certain arguments advanced for the utility of any non-Euclidean geometry in optical testing. Later in this paper, I shall develop this geometry fully, in all its mind-contracting intricacy. For now, I'll simply pick a few axioms and propositions to give the reader an idea of its essential nature.*

Some Axioms:

1. *A straight line segment can not be drawn joining any two points.*
2. *No line can be extended straightly in any way whatever.*
3. *There are a limited number of circles.*

Some Propositions:

1. *If two lines intersect, their vertical angles are not congruent.*
2. *Given a finite line of some sort, it may or may not be possible to construct some sort of figure . . .*

''Wait a minute,'' said Lansing. ''You say you lay out the whole system later?''

''That's right.''

''Isn't that beating a dead horse?''

''It's not called Bludgean geometry for nothing. But let me go on:''

Many say Lobachevskian geometry is useful in human studies (see D.W. Crowe, for instance) because of a famous experiment which confirmed that most subjects perceive a hyperbolic midline joining the midpoints of two sides of a triangle. But Bludgean geometry goes Lobachevsky one better, since it takes into account the reactions of all *the subjects, even if they missed the triangle entirely . . .*

Bludge was out at the gymnasium training trainers on his own time and Stacey and Lansing were sitting in the living room of Earthling House, playing checkers, when the red box at the end of the tachyon link turned the main console's printer on. Lansing, a very serious checkers player, seemed not to hear the chattering, but Stacey couldn't resist. He leaned over, ripped the message out of the printer, and placed it on the board:

JOURN. INTERST. OPT.

EY 6/30/2439

Appreciating the very interesting articles which may not be suitable for publication in this journal of Joseph Stacey and Dwight Bludge. Occurring now are considerations of both. Communicating more with both authors soon.

Longing to keep you in tightest embrace, M'mq Fp

''M'mq Fp?'' coughed Lansing. ''Who's that?''

''The editor of the *Journal of Interstellar Optometry*. She's a F'flk.''

''F'flk?'' Lansing brushed the note off the table.

''You know. The grey, slimy ones.''

''Oh, them. Crown me.''

''Doesn't seem to say much.''

''No . . . '' Lansing paused in mid-

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jump. "Except the date on that thing was the thirtieth. It's already the eighth of July."

"Hmm. You're right. Wonder what the hang-up was."

"Seems to me the grey slimies are one of those races with a weird concept of time, aren't they?"

"Can't remember. Jesus, you're decimating me!"

"Did you ever get a look at Bludge's paper?"

"Uh-huh," Stacey said. "I sneaked into his office and pulled it up on his screen. It's almost totally devoted to his treatment program—he barely touches on the mathematical background."

"He's probably ashamed."

"I doubt that. But he is being damned cautious. You know what, Al? You got me beat. I concede."

The printer began chattering again.

"What the hell?" grunted Lansing. They both got up and stood over the machine, watching it print out:

JOURN. INTERST. OPT.

EY 7/5/2439

Grieving that very interesting article by Dwight Bludge is not suitable for publication in this journal. Occurring now is review of very interesting article by Joseph Stacey by expert board:

Pq Mp, F'flkna iv, Grand Vizier, Math. Dept., F'flk U.

Voob, Lalande 21185 i, Editor, Big Truths

Rarshudarturiek, Jughead's Star ii, esper grade 9.

Communicating soon.

Longing to keep you in tightest embrace, M'mq Fp

"Rejected!" Lansing exclaimed. "That's even better than we hoped for. They'll print your paper by itself."

"I don't know. Why would they need a math expert to check out something like Bludgean geometry? And why the editor of *Big Truths*? I'm beginning to get a bad feeling . . . "

"Aw, simmer down. You're just getting writer's jitters."

"Hey," Stacey said, "I just remembered what the F'flk do with time. At least, if I'm remembering their system and not some other, nothing happens until a decision is reached. Then everything that has happened becomes real, if you follow me. We should be finding out in a few minutes."

The speaker behind the red box buzzed for attention.

"There it is," said Stacey.

"A voice link. That's expensive! They must have accepted."

Stacey hit the button to put the call through.

Out of the speaker came the warble of an oboe, saying, "I am Voob making ready *Big Truths*. I am mouth-thinking with great, but modest mathematician Dwight Bludge?"

"Oh, no," murmured Stacey. "I knew it."

Lansing poked him in the back. "Answer him."

"Mr. Bludge is out at the moment," said Stacey.

"Pitiable," said Voob, "to have missed the honor. Perhaps another time. Who do I mouth-think with now?"

"I'm Joseph Stacey."

"Ah! The genius mathematician's great admirer! This too, is honor. Without your discovery of him, may never

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have received genius geometry in this lifetime.''

Lansing returned to his seat and sat down, hard. ''I don't believe it,'' he said.

''You will pass my mouth-thinking on to your great mentor?'' Voob went on.

''Yes,'' said Stacey.

''You and Dwight Bludge will share 5000 kilos silver prize.''

''Huh?''

''Genius geometry can not be lonely in mere eye-book. Publishing math of your paper in *Big Truths*. Will, no question, win Lalande-yearly *Big Truths* Prize. No competition. Think: if great Bludge had less modesty and written out math himself, wouldn't have to share prize. Joke, huh?''

''Yes . . . uh . . . what about the *Journal of Interstellar Optometry*?''

''This is too big for eye-book. M'mq Fp gave to me.''

''But what about our work on the Hoon?''

''Ah! This work is very interesting, but not suitable for publication by M'mq Fp or self. I must breed now. Goodbye.''

The speaker clicked dead.

Stacey was feeling dizzy and weak again. He grabbed the back of his chair and sat himself down carefully.

''Well,'' he said dejectedly, ''I'm rich.''

''They think it's great,'' Lansing said, shaking his head in bewilderment.

''Maybe Bludge is a genius, after all.'' Stacey choked on a laugh.

''Nope. It's just like I said before. Bludge is the luckiest bastard in the universe.''

''It's not luck. We should have foreseen this. Six thousand races, each with a unique way of being intelligent.''

''Just because we should have seen it coming doesn't mean it isn't luck. After all, it still comes down to another breakdown in communication between the races. *Big Truths* is going to be pretty embarrassed after a few years, when everyone can see how sterile Bludge's system really is.''

Stacey felt more depressed than ever. His head drooped. He stared at his decimated checkers.

''Don't be so sure,'' he said with a sigh. ''When I think of all those different ways of looking at the universe — dammit, I can't help thinking that some race will find a way to put it to use.'' ■

● What we need is not less science and technology, but more, of the right kinds to replace the bad old ways. A problem—which we must take into account before we can hope to accomplish anything real—is that those old ways did not spring into existence, nor do they persist, for no reason at all.

Poul Anderson

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The Alternate View

SEXUAL DISCRIMINATION

G. Harry Stine

It might seem highly improbable that the widely different subjects of papermaking, weaving, pheromones, and agriculture could possibly be synthesized to produce a new means for controlling insect pests without harming human beings, much less the environment itself. But it's happened. It's an excellent example of intelligent use of technology, in addition to being an illustration of what author Arthur Koestler meant when he wrote that the act of creation is the "bi-sociative synthesis of random matrices."

For centuries papermaking has been the developing technology that produces the composite material upon which these words are printed. Cellulose fibers from trees and other sources are laid out in a random manner to give strength and body to paper. This is usually done on a fourdrinier-style paper machine that is capable of producing a sheet of paper more than 10 feet wide at speeds of several thousand feet per minute. It's a very old technology whose foundations were laid in China. Without the technological capability for mass production of paper, Gutenberg's moveable-type printing press would have been an interesting but useless piece of technology waiting for other technologies—namely papermaking—to catch up with it.

Weaving is another old technology/art. It was one of the first to become industrialized, because it's most important that we have clothing to keep us from freezing to death or dehydrating in the sun. Weaving is also an industrial process involving the manipulation of fibers. However, weaving produces a material whose fibers are definitely aligned.

It's not immediately apparent that mass production of paper couldn't be a reality without weaving. Weaving produces both the fourdrinier screen on which the pulp stock is deposited and the woven felt blankets that support and carry the wet paper web through the press rolls and drier rolls of the paper machine. (The utilization of jargon identifies me as one who's familiar with the process; check "Paper Making" in the *Encyclopaedia Britannica*.)

Meanwhile, back on the farm, cotton growers have been fighting the pink boll worm for centuries. Chemical pesticides came along that would kill the pink boll worm—and every other insect in the cotton field, including those considered "beneficial" like the green lace wings, which are the natural enemies of boll worms and other pests that like to eat cotton plants or deposit their eggs in the cotton boll. Most pesticides are also harmful in various ways and to various degrees to human beings. When the Environmental Protection Agency came along, pesticides became a no-no for use anywhere they might affect human beings. So here's the poor farmer without any way of controlling insect pests in his cotton crop. (Cotton itself is an outstanding natural fiber with a huge

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world market because it makes such good fabric. Cotton fabric is much superior to man-made fibers in many ways, the most important of which is the fact that cotton fabric is cooler to wear in warm climates.)

While all this was going on, entomologists and biochemists were unravelling a knotty problem: How do insects locate one another to mate, and how do they know which is male and which is female? They discovered that insects (and *all* animals, including human beings) secrete a chemical known as a "pheromone," which produces a distinctive scent. Either the female or the male of the species produces a pheromone as a way of saying, "Come up and see me sometime, preferably *now!*" If you've ever had a house pet in heat, you'll know what a pheromone does. You can't smell it, but every dog or cat within miles will and does . . . and tries to carry out the reproductive programming in its PROM. The pheromone from a bitch in season affects only male dogs, and it does an excellent job of this.

Then someone engaged in an intellectually creative act bringing together the hitherto unrelated fields of pest control and pheromones. Why not saturate a cotton field with the synthetic pink boll worm pheromone "gossypure"? This would require only about 15 to 30 grams per acre. Even with the increased price of the pheromone, its very low application rate would make it cost-competitive with pesticides. The pheromone would prevent the male member of the species *Heliothis zea* from locating the female of the species and thus prevent most of the mating and reduce the number of leaf-penetrating larvae. It wouldn't affect any other insect, and it would be harmless to human beings. In other words, it would create sexual discrimination of the strongest sort. (Pity the poor male pink boll worm moth! What a dastardly act! It's like running all the hookers out of town and replacing them with human pheromones and full-sized photographs.)

But this don't work, Charlie. Pheromones are by their very nature highly volatile. Spray them from an ag-plane on a cotton field, and the pheromones go away in a matter of hours or less. They have no staying power. They evaporate rapidly.

Albany International Corporation, founded in 1895, is a leading manufacturer of papermaking felts and other "engineered fabrics." They're the world's largest manufacturer of fabric to cover tennis balls, for example. In 1974 they set out to find other commercial applications for hollow fibers they'd developed for a reverse osmosis sea water desalinization process. An inquiry from a university professor concerning the feasibility of using regenerated protein fibers as a controlled release vehicle caused Thomas W. Brooks and Mike Coplan of Albany International to look at their hollow fibers as a controlled release system for volatile and expensive substances such as pheromones and fragrances.

The result is a product called No-Mate™. It consists of hollow plastic fibers a few thousandths of an inch in diameter and about three quarters of an inch long, filled with gossypure, the synthetic pink boll worm sex pheromone. The fibers are coated with an

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adhesive that makes them stick to cotton foliage. Special dispensers were designed to permit aerial application of NoMate™ from aircraft. An application of about 15 grams per acre is all that's required. The numerous fibers, each emitting pheromone, confuse the male moths so they can't find females and fertilize eggs. By mixing a small amount of pyrethrin insecticide with the NoMate™, its effect is amplified with little or no effect on pollinators or such beneficial insects as wasps, green lace wings, and lady beetles. And, of course, it has zero effect on human beings living nearby.

Since 1979 thousands of acres of cotton in Arizona and California have been treated with NoMate™. It works. Fields treated with ordinary insecticides produced an average of 3.4 bales per acre, while those treated with NoMate™ produced 4 bales per acre. Farmers who used NoMate™ ended up spending 17% less for insect pest control.

Albany International is now working on other pheromone release systems to control the artichoke plume moth (gourmets please note), tomato pinworm, and gypsy moths.

With many people yammering about the bad uses of technology today, this is an outstanding example of how to use technology wisely, to solve problems instead of wallowing in them.

It's also an excellent example of the proper use of the alternate view. Somebody looked at the problem from another angle. They were truly creative when they combined the seemingly unrelated fields of papermaking, weaving, entomology, and biochemistry. The result is both clever and elegant.

It takes a truly intelligent person to make such a synthesis in response to a social need. But it takes an enlightened person to recognize that such Golden Fleece projects as studying the sexual habits of insects and researching tiny hollow fibers for water desalinization may eventually lead to a whole new, environmentally safe means of controlling agricultural pests.

This leads to a follow-up series of questions. How do we teach people to make such grand syntheses in the first place? How do we convince those who cannot do such things that information is the most valuable thing in the world? How do we train people to search out and *use* this information? How do we communicate, file, and locate such information quickly in a world where the total amount of human knowledge doubles every seven years?

If such solutions as NoMate™ can be found, *what other solutions* to pressing problems can be discovered by taking an alternate view of them?

Look at what I just did to you in this column: I hooked you with a provocative title, and we ended up talking about something totally different from the subject implied. If you don't know it already, this is the way that most *good* technology is developed.

Science is a different matter entirely, by the way.

But that's another column some day. ■

● Morality is simply the attitude we adopt to people we personally dislike. Oscar Wilde

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Anyone with one set of abilities and limitations is likely to envy someone else's—but trying to imitate may not be the best course.

DARK THOUGHTS AT NOON

Timothy Zahn

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Like a crazed hawk the Piper Comanche dives at me through the red mist. I am flying her; desperately, I grip the wheel, trying to keep the car's screeching tires on the road winding through the mountains. Agony clouds my vision, permeates every fiber of my being. In the distance I hear a bell ring. Ask not for whom the bell rings . . . no, that's not right, but I can't remember how it should be. Beneath me the road sweeps past/the toy-like mountains crawl past. I am Dale Ravenhall/I am Nelson Follstadt/I am Dale/I am Nelson—pain pain pain. *The bell rings again—*

And as quickly as it began, the daymare was over. I was back in my house on the outskirts of Des Moines, trembling slightly with reaction. Downstairs, the front doorbell rang.

I took a deep breath and got up from the desk chair where I'd been sitting, feeling my shirt stick to my back as I did so. I headed out of the room, and was halfway down the stairs when the call came.

Dale, are you all right?

It was Colleen, of course; she's usually the only one who can tell when I've hit one of my daymares. *Sure, Colleen,* I assured her. *It wasn't too bad this time.*

At a hundred thirty-odd miles away in Chillicothe, Missouri, she was still far enough away for me to edit the thoughts I sent her, but even so the fib was a waste of time. *Oh, Dale,* she sighed, and I instantly felt like a heel as warmth and strength flowed from her, chasing away the final bits of the vision's darkness. *It'll get better, darling—it* has *to. Do you want to tell me about it?*

Not really. I'd found out months ago that talking about the daymares didn't do anything to eliminate them. *Look, honey, there's someone at the door. I'll call you back when I'm free.*

All right, if you're sure you're all right. I love you.

I love you, too.

We broke contact, and I felt the usual frustration well up inside me. Frustration at my daymares, at Colleen's quiet refusal to return to her beloved Saskatchewan as long as I still needed her close by; but most of all, frustration at the universe's uncaring decree that had kept us apart all our lives. And once more I swore I was going to find a way around that law, no matter what it cost me.

I continued down the stairs, and as I reached the front hall I caught the first wisps of thought from those waiting outside my door. There were two of them, one of whom I recognized almost immediately from the texture of his surface thoughts. The other was a stranger, but knowing Rob Peterson had brought him here made his business obvious. Reaching the door, I opened it wide. "Come in, Rob; Mr.—ah—Green," I said, pulling Ted Green's name from Rob's thoughts.

Green blinked, and I felt him reflexively shrink back as he realized what I'd just done. Rob just grinned and strolled on in; after four months of working for me he'd long since gotten used to telepathic shortcuts. With only a brief hesitation and a measuring look at me Green followed. Pretending I hadn't noticed, I closed the door behind them, then led the way to the living room. We sat down, and I got right down to business.

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"First of all," I said, addressing Green, "what has Rob told you about my project?"

"Nothing, really." He shrugged. He'd taken the farthest chair from me that courtesy permitted, and while he wasn't quite out of range there, the thoughts I could get were barely surface ones. But Rob was closer, and his thoughts verified Green's words. "He told me you needed something electronic built, and that I'd be working with the most intriguing bit of gadgetry I'd ever see." He smiled shyly. "How could I pass up a come-on like that?"

It was right then that I decided I didn't like Ted Green. The shy smile was pure affectation, completely out of sync with the cool, calculating mind I'd already glimpsed there. That sort of gambit used by that sort of person, I've found, is usually an attempt at emotional manipulation, a practice I detest. "How indeed," I said shortly. "Before I tell you more, I want it clearly understood that this information is strictly confidential, and that whether you take the job or not you'll keep it to yourself."

"I understand."

"All right." I pursed my lips, mentally preparing myself. I didn't want another daymare now. "Have you ever heard of Amos Potter?"

"Sure," was the prompt reply. "He was a telepath from California—worked as a psychologist, I think. He died last April during a plane hijacking, stabbed by one of the hijackers. Seems to me that was just a few days before your own accident, wasn't it?"

I forced a nod. Amos hadn't been killed by the hijackers, but had been forced into suicide by a megalomaniac Nelson Follstadt; and my "accident," as he called it, was Nelson's attempt to do the same to me. But there was no point in telling Green how much of the story the official version had left out. "Amos also had a master's degree in electrical engineering, and he left us an interesting device: a black box that locates telepaths."

Green blinked with surprise, threw a glance at Rob. "I'll be da— sorry. How does it work?"

I gestured to Rob. "We don't know yet," he said. "Most of the electronics are perfectly straightforward, but there are two components that Amos apparently made himself. They're the heart of the finder—and we still don't know how they work."

"Interesting," Green murmured. He looked at me. "May I see them?"

"Sure. The workroom's in the basement; the stairs are around that way."

I let Rob lead the way downstairs, bringing up the rear myself. Green, I noticed with grim amusement, practically walked on Rob's heels in an effort to stay as far away from me as possible.

I'd only lived in the house for about five months, having moved in just after my return from California with the telepath finder, and the basement thus hadn't had nearly enough time to fill up with ordinary homeowners' junk. That was just as well, because with the workbench and electronic gear Rob had brought in the place was already pretty crowded. In the center of the table, wired to an oscilloscope, was a crabapple-sized lump of metal.

"That's one of them," Rob said, pointing it out. "We've got seven

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—Amos left us eight but I ruined one getting it open."

Green stepped over to the table and carefully picked up the sphere. "Heavy," he grunted. "What'd you find inside?"

"A couple of commercial IC chips, an inductor coil he apparently wound himself, and some components that unfortunately were connected somehow to the inside of the shell and which I ruined when I cut it open. But we've got lots of data on its characteristics."

Rob pulled over a fat lab notebook and within ten seconds the two of them were embroiled in a technical discussion about six miles over my head. I didn't even bother to try and follow it; I was more interested in learning as much about Green as I reasonably could. Moving to within two or three feet would have given me complete access to both his surface thoughts and a lot of the stuff underneath, but he was keeping me in the corner of his eye, and I didn't want to push him too hard. So instead I kept my distance and worked on picking up the high points of his personality.

He wasn't going to be as easy to get along with as Rob had been; that much was obvious right from the start. Along with his manipulative tendencies, Green had more than his fair share of egotism, ambition, and something I took to be contempt for people he considered inferior to himself. But he seemed smart enough, if the speed at which he assimilated Rob's pages of numbers and graphs was any indication, and Rob at least seemed to think he could be trusted to keep my secret. If he was willing to work for the pittance I could afford to pay, I decided at last, the job was his. His personality I could live with or stay clear of.

After a while Rob ran out of words, and Green turned back to me. "I think I understand," he said. "These kernel things apparently act as antennas for whatever it is you guys broadcast, covering a broad enough spectrum to pick up all of you and plot a resultant. I gather that it works; so what do you need me for?"

"I want you to use those—kernels," I said, adopting his term for Amos's gadgets, "to design and build something entirely different. You'd be working mainly for the challenge of it, though; I can't afford to pay you much."

"Which is why you wanted another grad student instead of hiring a real EE," Green nodded. His tone was noncommital, but I could tell he was already hooked.

"More or less. Having known Rob for the past four years helped, too. All right. What I want is a device that'll block my telepathic ability."

Green frowned. "You mean like something to make the broadcast directional?"

"No—something to kill it altogether, the way a copper shell around a radio transmitter will absorb the signal."

"But why would you want—" He broke off, having answered his own question with impressive speed and accuracy, even given that my long-distance romance with Colleen was reasonably well known. "Temporary blocking, I assume?"

"Right." Though there were times I'd wished to be rid of the damn talent permanently. "When do you want to start?"

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"I haven't said yet I'd take the job," he said, a bit testily. I hadn't been wrong earlier; he didn't much like having his mind read.

Rob, as usual, saw the humorous side of his friend's reaction and chuckled. Green flashed him an annoyed look, then managed a wry smile. "Right—I don't *have* to say things like that here, do I? Okay. How about if I come in Saturday morning—say around eight-thirty?"

"Sounds fine. I'll see you then."

I leaned against the front door for a minute after I let them out, feeling the contacts fade as they walked to the street and Green's car. I knew I should be happy I'd found a replacement for Rob so quickly; it was only a week ago that he'd realized how much preparation his upcoming prelims were going to take. And yet, despite Green's apparent qualifications, there was something about him that made me uneasy. There'd been something going on beneath the level I could read, something . . . *sinister* was far too harsh a word; maybe *opportunistic* fitted the sense of the feeling better. I probably should insist on a deeper probe into Green's mind before I let him examine Amos's devices further, a part of me realized. But my pragmatic side quickly scotched that idea. As long as he made me a telepathy shield it was a matter of supreme indifference to me what kind of schemes his ambitious little mind might be hatching.

Sighing, I pushed away from the door and headed back to the living room. Patience is a virtue, I told myself firmly. Flopping down on the couch, I put it carefully out of my mind and reached out. *Colleen?*

I'm here, Dale, her answer came immediately.

We talked for a long time, and the afternoon shadows were cutting sharply across my minuscule lawn by the time we broke contact. Spending time with Colleen invariably improved my mood, and I was sorely tempted to ignore my psychologist's standing order and pretend the latest daymare simply hadn't happened. But reason eventually prevailed. Hauling the vision out of my memory, I went over it with a fine-tooth comb. By the time I finished I was depressed again, a mood I'd had to put up with a lot lately—Nelson had always been the melancholy sort.

If only I'd had a telepath shield five months ago. . . .

Whatever other qualities Green might or might not have possessed, I had to give him full credit for punctuality; he arrived on Saturday at eight-twenty-five sharp. I took him downstairs and spent nearly half an hour showing him where all the equipment and supplies were. He still tended to shy away from close contact with me, but since his personality hadn't changed markedly in the past two days such avoidance was mutually agreeable.

"So what are you going to do first?" I asked when I'd finished the grand tour.

"Double-check some of Rob's numbers," he said, pulling an ancient wave generator over toward the center of the table. "I want to see if flipping polarity on any of the kernel's bias terminals will affect the output the way he said it does."

I pulled a chair over to the far end of the work bench and sat down, resisting

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the urge to suggest that would be a waste of time. He already thought I was too impatient. "What will that tell you?" I asked instead, trying to sound merely curious.

"It'll tell me if energy is disappearing into the thing—if so, it may be acting as a transmitter instead of a receiver. Your shield might consist of one or more of these things blasting out an interference signal."

"Wouldn't it be easier to absorb the telepathic signals instead?" I suggested. "Then you could use them as receivers, the way they're designed."

"It might be," he said. "But I want to know my possible options before I start."

He returned to his work, his mind filling up with technical thoughts . . . but even so he couldn't hide the fact that his last statement had been at best a half truth. He had another reason for wanting to do this experiment, a reason I couldn't quite pick up at the distance I was at.

I thought about it for several minutes in silence. Two days ago I'd been willing to let Green do anything he wanted as long as he got me a shield, but now I was having second thoughts. After all, the telepath finder was Amos's final legacy to all the rest of us, and I had a certain amount of responsibility to make sure it wasn't ruined.

I puzzled at the question for a minute, then came to a conclusion. Leaning back against the wall, I sent out a call. *Calvin? Are you there, Calvin?*

Who's that—Dale? Calvin answered, a bit groggily.

I grimaced; I'd forgotten Saturday was Calvin's only morning to sleep in and that it was only a little after eight Pueblo time. *Yeah. Sorry, I didn't mean to wake you. I'll call back later.*

No, that's all right, he assured me. *I got to bed at a reasonable hour last night. What's on your mind?*

I wondered if Gordy had finished going through all of Amos's things, both at Eureka and at his mountain cabin. Specifically, I wanted to know if he found anything else relating to the telepath finder—notes, schematics; that sort of thing.

Um . . . you got me. I can call and ask, if you'd like.

I would, but you can wait until later. Whether he was in Eureka or at home in Spokane, Gordy would be on Pacific Time, and I had no desire to be the one responsible for waking him up this early.

Okay. Calvin hesitated. *I talked to Colleen yesterday. She said you'd had another daymare.*

Yes. It wasn't too bad, though.

Calvin didn't buy that any more than Colleen had. *Uh-huh. Any changes in the vision? Content, texture, length —anything?*

I sighed. *Not really,* I admitted, *unless you want to count the fact that my doorbell got incorporated into it. Aside from that it was just a straight replaying of Nelson's attempt to kill both of us. And before you try to think up a euphemistic way to ask, yes, I still get some of it from Nelson's point of view.*

He was silent for a long moment, but it wasn't hard to guess what he was thinking. Among the candle flickers of ordinary humans, we telepaths stand out like carbon-arc searchlights, the strength of our mental broadcast and sensitivity

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enabling us to communicate over hundreds of miles. But the price for this unique companionship is a heavy one: at anything less than a hundred miles apart the contact is strong enough to be painful, and at a theoretical distance of twenty miles both personalities would disintegrate totally under the strain. Nelson and I had been close to that limit when he finally took a wrong turn and crashed the plane he was chasing me with into a mountain. I'd survived the encounter . . . but not unscathed. The Dale Ravenhall I'd once been had been bent and altered by the force of the mental collision, changed into something that was part Dale and part Nelson. Permanently? No one knew. But the fact that some of each daymare still came heavily flavored with Nelson's memories was ominously suggestive.

Well, Calvin said at last, *it's only been five months, after all. A lot of simpler psychological problems take longer than that to heal.*

I snorted. *Thanks a whole bunch.*

Sorry, he said quickly, and I grimaced. In earlier days he would have recognized that kind of statement as the banter it was. Now, he was bending over backwards to avoid stepping on any toes, real or otherwise. Nelson had been the touchy sort.

It's okay, I reassured him. *I know you were trying to be encouraging. Uh . . . you don't have any plans to travel east in the near future, do you?*

I could come over any time. Why?—do you need some close-approach contact?

Not really. I wasn't ready yet to have all my surface thoughts open to another person, good friend or not. *I just thought maybe you'd be willing to stay in Minneapolis or Dubuque or somewhere for a week or two and let Colleen get back to Regina for a while.*

That could probably be arranged. Are her friends in Chillicothe getting tired of her company, or is she just homesick?

No *to the former;* probably *to the latter. Not that she'll admit it, of course —she takes her baby-sitting duties seriously.*

Uh-huh. Well, look—I'll talk to her and check the location log to make sure I wouldn't be flying in on top of anyone else and then get back to you. Okay?

Sure. Thanks; I really appreciate it. And don't forget to check with Gordy about any other telepath locater stuff.

Right. Talk to you later.

I came out of the contact and glanced around the room, reorienting myself. Everything was as I remembered it . . . except that Green was gazing sideways at me from the work bench, his expression wary. "It's okay," I assured him. "I'm not going to faint or anything."

"I know," he said. "Who were you talking to?"

"Uh—Calvin Wolfe."

"Pueblo, Colorado; right?"

"Yes." Frowning slightly, I touched his thoughts. What I found surprised me. "You've been reading up on us lately, haven't you?"

Again, there was that little flicker of resentment that seemed to come whenever I demonstrated my telepathic ability on him. "For a couple of days, yeah. I wanted to know what I was getting myself into. It must be nice to be able to talk to someone that far away so easily."

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"You can do almost as well by telephone," I told him shortly, "and without the disadvantages we've got."

He shrugged. "Not much of a disadvantage. All you have to do is stay out of each other's way. Big deal."

If I'd been a violent man I probably would've hit him. Instead, I suddenly felt a need to get far away from such stupidity. "I'll be upstairs if you need me," I told him with as much civility as I could manage. Without waiting for a response, I left.

The call I was expecting came about eight hours later, after Green had gone home for the day; and to my mild surprise it was Gordy himself who made it. *Gordy, where are you?* was my first question.

On a plane somewhere near Billings, Montana, I believe, he said. *I'm on my way to Minneapolis; going to be doing some work there for the next couple of weeks.*

Such fortuitous timing, I told him. *Calvin couldn't get away?*

Even eight hundred miles away I could sense his embarrassment. *You make it sound like we're all conspiring to put one over on you,* he protested. *We're your* friends, *Dale.*

Yeah, I know. Feeling like a heel was becoming a full-time job here lately. *What's the word on Amos's things?*

I've gone through everything from top to bottom and back again. No notes, no plans, no schematics, no extra equipment other than what you've already got. Either he deliberately destroyed all the documentation or the design of the finder was so obvious to him that he could just sit down and cobble one together. Sorry.

Me too. I thought about the implications of that. From Rob's struggles with the kernels I found it hard to believe they'd been *that* easy to make. Had Amos foreseen other applications for his invention, applications he perhaps hadn't cared for?

My telepath shield, for example?

Gordy broke into my musings. *Look, Dale, don't you think it's about time you let the rest of us in on what you're doing with all that stuff?*

My first impulse was to tell him that they'd find out when I was good and ready and not a solitary second sooner. But that was clearly Nelson talking. *I don't know,* I said instead. *I'm trying to make something new out of the things Amos developed for his finder. If it works—well, it'll benefit all of us. Let's leave it at that for now.*

Gordy was silent for a long moment. *You know, Dale, it's possible to play these things too close to the chest. If we'd known that Amos had caught Nelson making quiet trips to Las Vegas we might have implicated him in Amos's death before he had the chance to try and kill you. You could be running the same kind of risk here.*

I'm being careful, I told him stubbornly. My doubts about Green rose unbidden before my eyes; ruthlessly, I crushed them down. *I just don't want to raise any false hopes, that's all.*

All right, he said after another pause. *But be careful, okay?*

Sure. Enjoy your flight, and I'll talk to you later.

Yeah. Take care.

I sat where I was for a long time af-

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terwards, my book lying ignored on my lap. Once again I felt torn between my natural desire for caution and my almost suffocating urgency to possess a telepath shield. Colleen was practically within my grasp—how could I permit anything to get in the way of that? Besides, what earthly use would a telepath shield—or anything else Green could make in my basement—be to a normal person? A defense against the highly unlikely possibility of one of us eavesdropping on a private conversation? Ridiculous, when thirty feet of distance would achieve the same end. No—I *had* to be reading Green wrong . . . and I didn't need to be reminded that Nelson had had a strong touch of paranoia.

Nevertheless, that evening I went out and bought a burglar alarm, and by the time I went to bed I had it rigged so that anyone entering or leaving my basement would trigger a light and quiet buzzer in my second-floor study. Now, whenever Green tried to leave I would know in time to get within telepathy range of him before he got out of the house. A rather simple precaution, to be sure—but then, I wasn't really expecting any trouble.

The days lengthened into weeks, as days have a way of doing, and progress on the shield remained depressingly slow. Green's idea about reversing the biases hadn't panned out, and he'd been forced to seek out new approaches. Fortunately, he didn't get discouraged as easily as I might have, his failures merely spurring him to stronger efforts. He began to spend more and more time at my house, sometimes arriving while I was still eating dinner and not leaving until after midnight. What made his single-mindedness all the more astonishing was the fact that he still felt acutely uncomfortable around me, avoiding close contact and sometimes even going so far as to fill his mind with technical thoughts to try and forget I was within range. Apparently he was simply the type who enjoyed a challenge for its own sake.

I had a couple more daymares during that period, too, one of them while Colleen was back in Regina. Fortunately, Gordy was still in Minneapolis at the time and helped me get through those first few shaky minutes afterward. I'd wanted him to keep quiet about it, but he insisted that Colleen had a right to know, and the upshot was that she was back down at her Chillicothe listening post within twelve hours. I was pretty upset with her for interrupting her R and R, and I think it was probably that mood that triggered the milder daymare a day later. It was really little more than an aftershock, but it was enough for Colleen; after that, she wouldn't have left me again if the whole midwestern United States had caught on fire. Gordy, too, found reason after reason to stretch out his Minneapolis visit, and when he finally left, Calvin found a plausible excuse to spend some time in Dubuque.

What with all this companionship therapy taking up a lot of my attention, it was early October before I finally noticed something was off-kilter.

It began with an afternoon call from Rob Peterson, who was trying to get hold of Green and thought he might be with me. During the course of the conversation I discovered Green hadn't shown up at any of his classes for nearly

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a month, a figure that coincided uncomfortably well with the first of his six-to-midnight sessions in my basement. When I asked him about it later, Green admitted he'd been neglecting his schoolwork, but claimed he'd be able to catch up once he finished my shield. As usual, he stayed right at the edge of my range, so I wasn't able to confirm that he was telling the truth; and not wanting a scene I let him go back to work without further cross-examination. I soothed my conscience by reminding myself that he was a grown man, perfectly capable of deciding how to use his time.

But the whole thing seemed funny somehow—I couldn't reconcile this sudden neglect of his studies with the ambitious and calculating personality I'd already glimpsed in him. It bothered me; and gradually I began staying on the first floor whenever Green was in the house, where I could pick up his surface thoughts as he worked in the basement. He knew, of course—my footsteps would have been audible above him—and I could sense an almost frantic note in his attempts to cram his thoughts with technical details of his work. But enough got through. More than enough. . . .

I waited until I was sure, and then I confronted him with it.

"You've had it for two weeks now, haven't you?" I said, anger struggling for supremacy with other emotions I was afraid to accept. "You know how to make a telepath shield."

"I don't *know* if I do," he protested. Hunched over the workbench, a soldering iron still gripped in his hand, he watched me with slightly narrowed eyes, as a rabbit might a fox. "I've never tested it."

Hairsplitting; but it *was* a genuine lack of certainty, and that had been enough to fool me for nearly a week. Belatedly, I wondered if perhaps I'd gotten the rabbit and fox roles reversed. "Well, let's not waste any more time. Turn it on."

"All right." Standing up, he went to the far end of the bench. A bulky, three-level breadboard assembly rested there, built into a framework that looked like it'd been made out of leftover angle iron. Three of Amos's kernels glittered among the tangle of electronic components. Plugging the device's cord into an outlet, Green flipped a switch and vanished.

It took a fraction of a second for my eyes to register the fact that Green was, in fact, still standing there in front of me, that it was only his mind that had disappeared from my perception. I must have looked as flabbergasted as I felt, because Green's lip twitched in a smile of sorts. "Like it?" he asked.

"I—yes," I managed. "How does it work?"

"Best guess is that it creates a sort of dead zone where telepathic signals get absorbed. I don't know for sure, though."

"I told you that was the approach to take," I said, feeling a little lightheaded. "Will it block other telepaths, too? We project a lot more strongly than you do."

He shrugged. "Try calling someone."

I did; and because I was afraid of false hopes I tried for a solid three minutes. But at the end of that time I was con-

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vinced. *Colleen* . . . With an effort I dragged my mind back to Earth. One more important question still needed an answer. "All right. Now tell me what you've been doing these past two weeks, while you were supposedly working on the shield."

He radiated innocence. "I *have* been working on it—I've been trying to make a more practical model." He indicated the breadboards. "You see, this one is big and heavy, with an effective range of probably no more than a hundred feet, and it requires one-twenty line current. I think I can make one that would run off a battery and have almost half a mile of range—and the whole thing fitting inside a briefcase. Another—oh, month or so—and I should have it."

It was a good idea; intellectually, I had to admit that. But all of my hopes and dreams had suddenly become reality and I knew I didn't have the patience to wait another day, let alone an entire month. "Thanks, but no. This one will do fine."

He blinked, and I got the impression that my answer had surprised him. "But . . . I'm not finished here, Mr. Ravenhall. I mean, I promised to build you a practical telepath shield. *This* thing's hardly practical."

"It's practical enough for me," I said, frowning. Goosebumps were beginning to form on my suspicions—he had no business fighting that hard for a two-dollar-an-hour job. "Before we continue, what say we make things more interesting and turn off the shield?"

He made no effort to reach for the switch. "That's not necessary," he sighed. "I *was* bending the truth a little. I've actually been trying to design an entirely different gadget using those kernels, and I was afraid you'd send me away permanently once I'd finished the shield."

"What sort of gadget?"

"A mechanical mind reader."

"A *what?*"

"Well, why not? The kernels clearly pick up telepathic signals. Why shouldn't the signals be interpretable, by a small computer, say?"

I opened my mouth, closed it again as the potential repercussions of such a gadget echoed like heavy thunder through my mind. By necessity, each of us who'd had this gift/burden dropped on us had long ago thought out the consequences of misusing our power. The potential for blackmail, espionage of all kinds, or just simple invasion of privacy—I was personally convinced it was only our extremely limited number and the fact that we were thus easy to keep track of that had kept us from being locked up or killed outright. A mechanical device, presumably infinitely reproducible, would open up that entire can of worms, permanently. "Forget it," I said, finding my voice at last. "Thanks for the shield; I'll give you your final pay before you leave." I turned to go back upstairs.

"Wait a minute," Green snapped. "I *can't* forget it, just like that. This thing'll be a gold mine if I can get it to work. I've put a hell of a lot of work into it—I can't quit now."

"A gold mine for whom? You and a select clientele of professional spies?"

"It doesn't have to be that way," he protested. "Psychologists, for instance—mind readers would be a tremendous help in their work. Rescue

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teams could locate survivors in earthquakes or collapsed buildings. Doctors—''

''What about bank robbers? Or terrorists? Or even nosy neighbors?'' I shook my head. ''What am I arguing for? The subject is closed.''

Green expelled his breath in a long, hissing sigh, and his expression seemed to harden in some undefinable way. ''I'll have to collect my tools,'' he said stiffly.

I hesitated, then nodded. ''All right. I'll be upstairs writing your check.''

I didn't head up right away, though, but crossed instead to the dim corner where the fusebox was. The telepath shield I'd coveted for so long had abruptly become something that could be used against me, and I had no intention of letting Green leave here under its protection—I wanted to know whether he'd really given up or had something else up his sleeve. One of the peculiarities of this house was that the basement lights were all on one circuit and the outlets on another. Finding the proper fuse I pulled it . . . and across the basement, just barely within range, I felt Green's thoughts reappear. Simultaneously, drowning out that faint voice, came a frantic duet.

Dale! Are you there, Dale; can you answer?

Here I am, I said hastily. *What's all the fuss?*

Oh, thank heaven. Colleen's thoughts were shaking with emotion. *We thought something terrible had happened. Calvin and I have been trying to contact you for nearly five minutes.*

Another daymare? Calvin asked, trying to sound calmer than he really was. I didn't blame him; a daymare that had lasted that long would have been a real doozy.

No; this was something good *for a change.* I told them about the telepath shield, trying to recapture my earlier enthusiasm for the device. But that glimpse into Green's ambitions had dampened things considerably, and I was barely able to keep my report on the positive side of neutral.

Calvin, at least, saw the potential hazards immediately. *Do you think it's wise to let this Green character run around loose?* he asked when I'd finished. *If he can make a telepath shield who knows what else he can do?*

There shouldn't be any problem, I assured him. *Amos's special gadgets are the key, and he doesn't know how to make them. I'm sure of that, but I'll double-check before I let him leave.*

I don't know, Colleen mused. *I don't trust him. He sounded—oh, too ambitious, I suppose.*

My own thoughts skidded to a halt. *Wait a second. When did* you *talk to him?*

Last week. She sounded surprised. *He got my number here from my Regina answering service. Said he was calibrating Amos's finder and needed to know where I was. I assumed you knew.*

I frowned . . . and at that exact instant both Colleen and Calvin vanished from my mind.

It was so unexpected that I wasted a good ten seconds trying to reestablish contact before I noticed that the faint touch of Green's thoughts was also gone and finally realized what was happening. I spun around, but too late: Green's legs were just disappearing up the stair-

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well. Clutched in one hand was something that looked like a small briefcase.

With a shout, I went after him. But his lead was too big, and by the time I ran out my front door he was already diving into the front seat of his car. With a squeal of tires he took off into the night. Seconds later I was tearing down the street behind him, gunning my old Chevy for all it was worth.

And the chase was on.

At first I thought it would be over quickly. I caught up to him with almost ridiculous ease, as if his car was in even worse shape than mine. But as we cleared the edge of town his lead began to open up slowly, and by the time he turned south on I-35 he was staying a comfortable quarter-mile ahead of me.

For me the drive was like an inside-out version of that horrible race through the California mountains. The road here was flat, and I was the pursuer instead of the pursued; but the same sense of terrified urgency was wrapped suffocatingly around me. Clearly, Green had lied about the portable shield—and I, the great telepath Dale Ravenhall, so caught up in my own selfish desires, had let him get by with it. Bitterly, I wondered what else he'd lied about . . . and whether I'd ever get a chance to warn the others. His strategy seemed clear: by forcing me into a chase like the one in California he was trying to trigger a daymare, one that would undoubtedly be fatal even given the sparse traffic and relatively straight road. And with the shield going full blast in Green's car it would be a very lonely death. More than once I tried to drift back out of range, hoping to at least let Colleen or Calvin know what had happened; but each time Green spotted the maneuver and matched it. I wondered what he would do if I stopped completely, to either call Colleen or phone the police. But I didn't dare try it. If I let him out of my sight I knew I'd never see the shield or the rest of Amos's kernels again. Grimly, concentrating on Green's tail lights, I fought down the panic bubbling in my throat and kept going.

I don't know how long the chase lasted; my mind was too busy damning my shortsighted stupidity and fighting off potential daymares to think about time. Green got off the interstate at Osceola, heading east on 34. He didn't stay on the road long, though, turning south again on 65. Twenty-odd miles later he picked up a county road heading west, and from that point on I was thoroughly lost. I dimly remember that we were on some road labeled B when we crossed over into Missouri, but all the rest were just anonymous two- and four-lane roads, passing through or near sleeping towns with names like Woodland, Davis City, Saline, and Modena.

And finally, sometime in the small hours of the morning, Green pulled over to the side of the road and stopped.

I pulled up behind him, feeling a cold sense of satisfaction. He hadn't given me a daymare and hadn't lost me among the country roads of two states, and had now bowed to the inevitable. He was outside the car now, the briefcase he'd taken from my house held across his chest like a shield. I got out, too, and walked toward him, watching for concealed weapons. "All right, Green, it's all over," I told him. "Let's have the shield and whatever else you stole."

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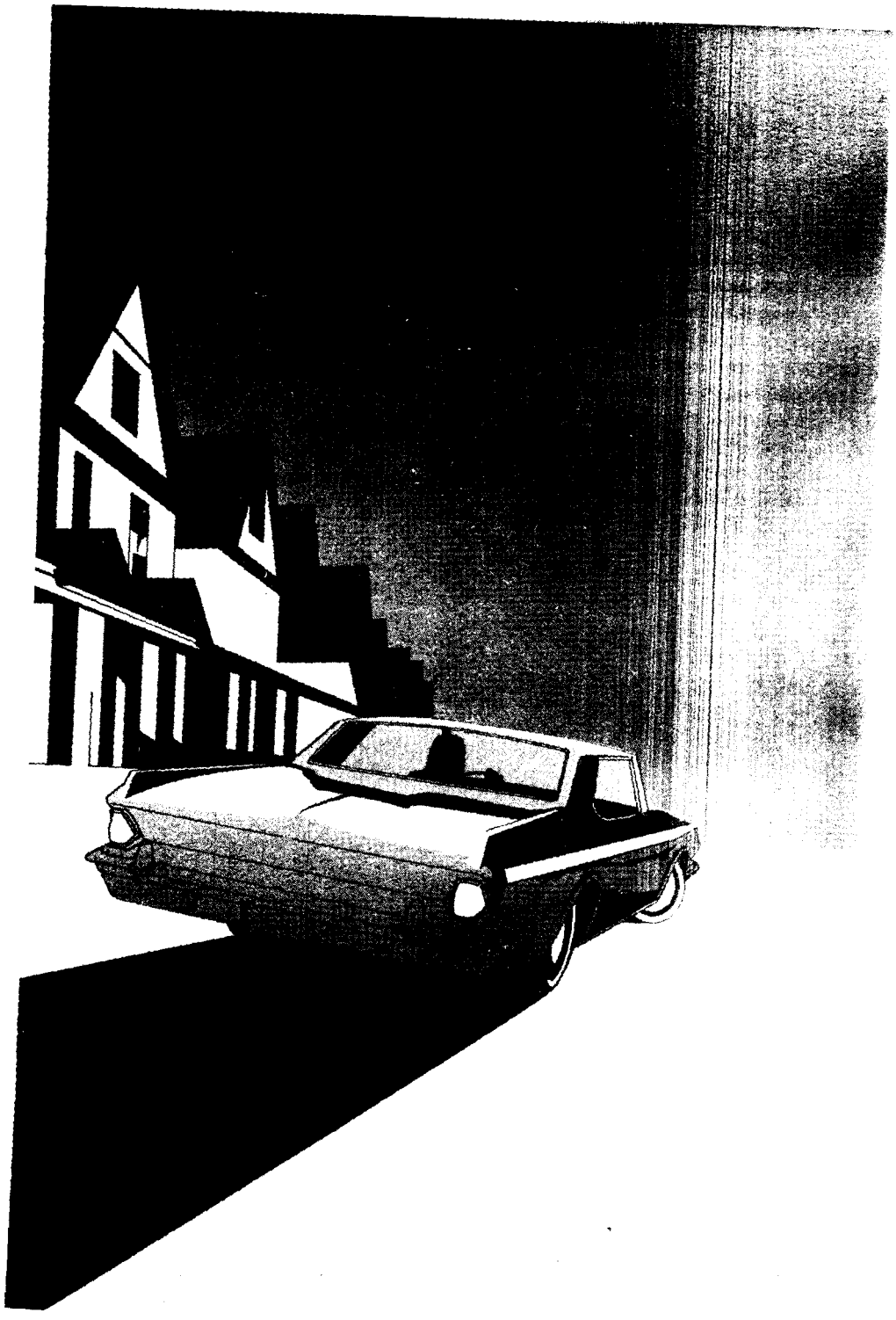

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In the headlights I saw him shake his head minutely. "Before you do anything hasty," he said, his voice strangely tense, "I suggest you look at the sign up there."

Frowning, I glanced over his shoulder. Highway 65 was cutting across the landscape directly ahead; a dimly lit sign along its side announced eleven miles to Chillicothe.

Chillicothe?

I felt the blood draining from my face as I refocused on Green. "Yes," he nodded. "She's within the twenty-mile limit. If I flip this switch you'll both be dead instantly."

The big toggle switch sticking out of the briefcase looked the size of a baseball bat under his hand. There was no way for him to miss it if I jumped him . . . and looking at his eyes I knew he was half expecting me to try just that. "All right, let's both relax," I suggested through stiff lips. "What do you want?"

"For starters, I want you and Colleen Isaac together. There's no point taking both cars; we'll go in mine. I hope you know where she's staying—all I've got is her phone number. You'll drive, of course."

"Of course," I said mechanically. *Colleen,* I thought. *What have I done?*

There was no answer.

She was waiting outside her motel room door when we pulled up, her expression drawn but controlled. I got out of the car and walked up to her. For a moment we gazed into each other's eyes. Then, almost of their own volition, our hands sought each other and gripped tightly . . . and a moment later she was in my arms. "It's all right," I whispered to her, trying to project confidence I didn't feel, and to hide the disappointment that—despite the danger we were in—I *did* feel. I'd had such romantic dreams about this moment, dreams that would now be forever poisoned in my memory.

Behind us, Green cleared his throat. "We'd better get moving," he said, sounding almost apologetic. "Both of you in the front seat, please."

"Just a second," I objected, turning halfway around but keeping one arm around Colleen. "Doesn't she at least get to bring a change of clothes?"

"She didn't seem surprised to see us," he countered. "That means she was expecting us. The police may be on their way right now."

"I wasn't expecting you." Colleen's voice was slightly higher-pitched than I'd expected it to be and had a slight accent. But it was steady enough. "We assumed you were using your telepath shield to stop Dale from talking with us, but I didn't suspect you were here until I was also cut off a minute before you arrived. I didn't call the police."

"But one of your friends might have," Green growled, showing signs of agitation. "Grab your purse and let's *go!*"

He didn't relax again until we were five miles out of Chillicothe, heading east on 36. I held Colleen's hand as I drove, though whether for her comfort or my own I wasn't entirely sure. Strangely enough, she seemed the calmest of all of us, and was the one who finally broke the brittle silence. "You know, Ted, this really can't gain you anything," she said, turning her head to the side so that Green could hear her.

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"By now every telepath on the continent knows about you and your machine."

"That's fine with me," Green grunted. "I'm going to need cooperation from all of you, anyway, so there's no reason to keep it secret. Except from the police, maybe. I hope no one's been stupid enough to call them."

"What is it you want?"

"An electronic telepath," I told her. "And he apparently wants us to sit around and watch him make one."

"I wish it were that easy," Green said. "But it's not. I figure I'll need at least ten kernels to make it, and even then it'll only be a one-way mind reading device—I can't get the damn kernels to transmit anything to speak of."

In spite of the danger, I felt a wolfish smile crease my face. "Ten kernels, huh? And you've only got four left—you left three in the shield in my basement. So you're licked even before you start."

"No!" His exclamation was so unexpected I jumped, nearly swerving out of my lane. "I can figure it out—could have figured it out. But you weren't going to let me." He paused, and in the mirror I could see him fighting for self-control . . . and it was then that I suddenly realized he was as scared as I was. He'd clearly been spinning some high-flying hopes for this particular rainbow, and my adamant opposition had apparently goaded him into an act of desperation that he wasn't really ready for. Now, he was beginning to see just how deep the hole was he was digging himself into.

Colleen must have sensed that, too. "Ted, you don't have to do this," she said. "Let Dale take me back to my motel and then leave him with the shield, and it'll be over. There won't be any charges or other repercussions; I promise."

"What about my mind reader?"

Colleen hesitated. "I'm sorry, but I'm afraid we can't permit Amos's invention to be used in that way."

"Then forget it."

"Green—" I began.

"Shut up," he said. "I have to think."

His ruminations took the better part of an hour, during which time he had me change roads twice. I kept my eye on him in the mirror, hoping he would fall asleep. But he remained almost preternaturally alert the whole time.

Finally, he seemed to come to a conclusion. "Ravenhall, 63 ought to be coming up pretty soon," he said. "Take it north."

"Where are you taking us?" Colleen asked.

"Back to Iowa. I know a little resort near Rathbun Lake where you can rent cabins. We can stay there for a while."

"Taking us across a state line is a federal offense," I pointed out to him.

"How do you figure? I'm not kidnapping you. If you want, you can both get out right here."

I didn't bother to reply.

What with the circuitous route Green made me drive we didn't arrive at the resort until after eight in the morning. My secret hope, that the place might be closed until spring, was quickly dashed; either the warmest October in thirty years had induced them to stay open past their usual closing date or else they catered to the kind of hikers and fishermen who ignore the weather anyway. Green left us alone in the car while he

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went in the office to register. I tried to think of a plan—any plan—while he was gone. But it was no use. I'd been driving all night, much of it at the edge of nervous prostration, and my mind was simply too fatigued to function. Even as I drove up the gravel road to our cabin I felt my consciousness beginning to waver, and I just barely remember staggering through the front door with Colleen holding tightly onto my arm. Somehow, I assume, she got me to the bed.

I came up out of the darkness slowly and unwillingly, glad to escape the nightmares that had harassed my sleep but dimly aware that something worse was waiting for me in the real world. I opened my eyes to an unfamiliar ceiling, and even before Colleen spoke it had all come back.

"How are you feeling?"

I turned my head. She was sitting in a chair next to the bed, light from the window behind her filtering through her hair in a half halo effect. "Groggy," *I told her. "How long did I sleep?"*

"Almost ten hours. I didn't see any point in waking you."

I looked at my watch. Six-oh-five. My stomach growled a reminder that I'd missed a couple of meals. "Did you sleep at all? And where's Green?"

"Yes, I took a couple of short naps. Your friend's out in the living room."

"He's no friend of mine." I turned my head the other way and realized for the first time that the cabin wasn't the simple one-room design I'd expected. Colleen and I were in a small bedroom that took up maybe a third of the cabin's total floor space. The door that sat between us and Green looked solid enough, but it opened inward and had no lock that I could see. I wondered how Green thought he could keep us in here.

"Don't try the door," Colleen said, as if she'd somehow penetrated the shield and had heard my unspoken question. "He has the switch on his telepath shield fastened to it with a piece of string. He sealed the window, too."

I hesitated halfway through the act of rolling out of bed, then continued the motion and got to my feet. Walking around the end of the bed, I went to the window behind Colleen. He'd sealed it, all right; a dozen nails and screws had been driven through the wooden sash and into the frame.

Behind me Colleen's chair creaked, and a moment later her hand tentatively touched my arm. "Dale . . . what does he want with us?"

There was no point studying the window any further; it was clear that without a screwdriver and claw hammer I would never get the thing open. Turning around, I faced Colleen, taking her *hands in mine. "You heard him—he* wants a mechanical mind reader. I gather he thinks we can help him make one."

"How? Does one of us have something he needs?"

I shook my head. "I don't know." It was odd, a disconnected part of my brain thought, how small a part of its target a camera could really capture. I had hundreds of photos and videotapes of Colleen, but not a single one of them had done her justice. Even tired, hungry, and with a horrible death crouching like a leopard over her shoulder, there was a vivaciousness about her that the

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films had never really showed. I'd known her energetic joy of life through her thoughts, of course; but to see it reflected in her face was an entirely new and delightful experience. If we died now, I would have had at least that much.

If we died now. The thought short-circuited my rising romantic mood and brought me back to Earth. There were a dozen questions that urgently needed answering. Giving Colleen's hands a squeeze, I let go and walked back around to the door. "Green?" I called through the panel. "You awake out there?"

"Come on out," was the immediate response. "The door's safe to use."

I opened it and stepped into the main part of the cabin, noting in passing that Green's booby-trap string was not tied to the doorknob but to another nail driven into the door at knee level. Green was sitting on a small couch across the room, a glowing lamp at his shoulder. On his lap, the switch close to hand, was the telepath shield.

"I thought you weren't ever going to wake up," Green commented. "There're some hamburgers in the sack on the table—you can heat them up in that one-quart oven over there. Cokes are in the fridge."

I was too hungry to bother with the oven. Colleen, with a lower tolerance for American fast food, took her burgers and headed for the cabin's tiny kitchenette. Green waited until we were settled at the table before speaking again. "I've been making a list of the equipment I figure I'm going to need," he told us, holding up a piece of paper clearly torn from a second hamburger bag. "I figure that with a small x-ray machine I can figure out how everything is put together inside one of these kernels. If not, there are a couple of other things I can try. A good computer would be helpful in designing the mind reader's circuitry, and since I'll probably need one anyway to interpret the telepathic signals we might as well get that, too."

"Just where do you expect to get the money for all of this?" I asked around a mouthful of food. "If you're expecting the rest of the telepathic community to fork it over, you can forget it. None of us has the resources you're talking about."

"You fly all over the country whenever you want to, don't you?" he scoffed. "That isn't exactly cheap."

"Most of us have small stipends from universities that are studying us," Colleen explained to him. "The amounts aren't nearly enough to supply you with x-ray machines and computers, though."

Green's mouth twitched. "Well . . . then I guess you'll have to earn the money some other way."

"Such as?" I asked. Most businesses, I've found, aren't all that enthusiastic about having telepaths on the payroll.

"I suppose industrial espionage would be the most profitable," he said, watching me closely.

If he was looking for a reaction, he wasn't disappointed. Some bread crumbs tried to go down the wrong way, and it took me half a minute to cough them out. "Forget it," I snarled when I could talk again. "If you think we're going to do *that*—"

Colleen cut me off with a hand on my arm. "Ted, we can't do that," she said,

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her voice calm and reasonable. "We're all rather well known; certainly the security departments of any major corporation would recognize us instantly."

"Then you'll have to hit key employees at off hours," Green said stubbornly. "Or else wear disguises. I *need* that equipment—don't you understand?"

"And what about us?" Colleen asked. "Don't you see what involving us in crime would do to the trust we've built up between ourselves and the general populace? We can't survive without that good will, Ted."

"I'm sorry. I really am. But it's not my fault." He shifted his gaze to me, where it became more of a glare. "If *he* hadn't been all noble and virtuous and had let me keep going, none of this would have happened."

"Oh, sure—blame it on me," I growled. "Why not blame your parents, society, and the planet Jupiter while you're at it?"

He ignored me. "I want to know how to contact Calvin Wolfe—I know he's a friend of yours and his Pueblo phone's unlisted. I also want something I can say to him that'll prove you two are with me."

My mind raced. Was there some way I could slip in a clue as to where we were? Rathbun, reservoir, lake—I couldn't think of any way to code any of those words so that Green would miss it. I'd never been here before, so referring to a past visit was out. Distance from Des Moines? I hadn't the foggiest idea. I was still trying to come up with something when Colleen gave him Calvin's number and unconsciously undercut my effort. "Just give him your name," she told Green. "He knows who you are."

"Okay." He stood up and gestured toward the door. "We'll have to find a phone booth to make the call from; I don't want anyone tracing us here."

It was an hour before we got back to the cabin, Green having taken us halfway to Ottumwa to get the distance he wanted. We were left in the car while he made the call, and he wouldn't tell us anything about it afterward except that Calvin had agreed to take up the matter with the rest of our group.

"Do your think that's the truth?" Colleen asked me when we were locked again in the relative privacy of our room.

"Probably," I told her. Outside the window the evening had faded into night, and the lights from two or three other cabins could be dimly seen through the trees. Too far away to see a signal, even if I could think of some way to send one without tipping off Green. "Calvin would agree to anything at this stage to gain time." Pulling the shade, I turned on the light and sat down on the bed next to Colleen. The light switch had gone on with a loud click; no quiet SOS possible with that. "I just hope we don't get some gung-ho SWAT team bursting in with M-16s blazing."

"I doubt if there's any danger of that," she sighed. "We'd already decided to keep the authorities out of this when the shield cut me off."

I nodded; I'd rather hoped they'd seen things that way. At the moment no one but us knew it was even possible to build an electronic mind reader. If the word ever got out, chances were *someone* would eventually figure out how to do

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it. "Good. I guess. Anything else happen while I was out of touch?"

"Yes, but nothing that'll help us here." She shifted position to stretch out on the bed, closing her eyes against the overhead light. "I called your friend Robert Peterson on the phone and asked him to go over to your house and see what was wrong. He called me back on your phone with the news that your car was gone and your house lit and unlocked. Calvin wanted to know whether there was anything there that could be a telepath shield. Robert said there was a heavy monstrosity in the basement that had three of Amos's devices wired into it, but that he couldn't tell what it was without more study."

"Yeah. How *do* you test a telepath shield?"

"Obviously, with a telepath. Gordon was going to catch the next plane to Des Moines, and Scott will most likely come up from New Orleans now that I've also disappeared. He was anxious to get involved and has always rather liked me." She opened her eyes briefly. "Something I just thought of: could Robert modify Amos's telepath finder to locate a *lack* of telepathic signals?"

"Like this shield?" I shrugged. "I don't know, but I doubt it. We had to take apart the finder to get parts for the shields; Rob would have to rebuild as well as redesign it. And, anyway, he hadn't gotten much into design work when Green took over." A fresh wave of shame and anger washed over me. "I should've waited until Rob was available again," I muttered.

Colleen was silent for so long I began to think she'd fallen asleep. Turning off the light I lay down beside her, hating both Green and myself and wondering if I was tired enough to escape into sleep myself for a few hours. Then Colleen stirred. "Dale . . . why did you do it?"

It took me a moment to understand what she was asking. "For us," I told her. "I wanted to be able to see and hold you, to share more than just my thoughts with you. I—when I say it like that it sounds pretty selfish, doesn't it?"

"A little," she admitted. "More like Nelson Follstadt than Dale Ravenhall."

I sighed, closing my eyes in an effort to block the sudden tears forming there. Nelson again—always it was Nelson. Was I never going to be free of him? Or were my motivations and judgment going to be forever skewed by what he'd done to me in the California mountains? It was like carrying my own personal ghost along with me, someone to foul up everything I did, someone—

Someone to blame.

The thought leaped out at me with almost physical force. Was I using my psychological injury as a scapegoat, a convenient excuse whenever anything went wrong? I didn't really believe it — certainly didn't *want* to believe it. But the possibility was there . . . and blaming other people *had* been one of Nelson's most annoying traits.

And I'd just argued myself in a circle. I never argued in circles. Or, rather, Dale Ravenhall never had. . . .

Colleen's arm slid over my chest, breaking through the spiral of fear and self-pity. "It's all right, Dale," she said soothingly. "We'll get out of this somehow."

For a long time she held me tightly, as if comforting a child. Gradually, my black depression began to lighten; and

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as it did so my need for her changed, both in nature and urgency. Her response, whether from love, fear, or a combination of both, was so strong it surprised me . . . but within seconds surprise and all other emotions were crowded out by the passion exploding within me.

For the three years since I'd fallen in love with Colleen this moment had formed the basis of virtually all my fantasies . . . and yet, now that it was here, the act was tinged with an unexpected sense of frustration. It wasn't just the circumstances, or the presence of Green on the other side of the door, but rather the missing dimension that even the casual sex of my younger years had had. For the first time in my life I was cut off from the thoughts and emotions of my partner, forced to rely on the subtle physical cues I'd never really bothered to learn. I botched it—botched it badly—and though she didn't say anything I knew she was disappointed. I tried to apologize, but I couldn't find the words, and had to settle for holding her close until she fell asleep.

I stared at the shadows of tree branches swaying across the window shade for at least an hour after that, tired but not really sleepy. With time, I knew, I could learn to be a better lover to her—but time was the least certain commodity in our world just now. I wondered how long it would take Green to get the money and equipment he wanted . . . and I wondered how long the batteries powering the shield would last.

Eventually, I fell asleep.

We both woke fairly early the next morning. That turned out to be a mistake, because the day quickly became one long study in boredom. Green had slipped out before we woke and had brought back donuts and coffee and the necessary ingredients for sandwiches. That last was a disappointment; I'd hoped for the chance to break the window and escape when he left to buy lunch. But as usual, he was one move ahead of me.

To his credit, he also brought back a couple of decks of cards and three paperbacks of the sort found on grocery store book racks. But neither Colleen nor I was great shakes as card players; and I, at least, was too wrapped up in my own real troubles to have any patience with someone else's fictional ones. Besides, the covers of the books strongly suggested they contained a fair amount of sex and/or romance, and after the fiasco of the previous night I knew I wouldn't be able to handle that.

So instead of reading I spent some time going over our room, searching for something I could use as a tool or weapon. It was a small room, though, and it wasn't even eleven o'clock before I gave up.

Mostly, Colleen and I talked.

There wasn't much about each other we didn't already know, of course; but good friends can always find something interesting to talk about. We discussed world topics, history—one of Colleen's pet interests—and our fellow telepaths, and reminisced a good deal about the five years we'd known each other. By a kind of unspoken agreement we avoided talking about our current situation, but the very fact we were using spoken words at all was a continual reminder of what was happening. I could feel a

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tenseness in Colleen's body as we lay side by side on the bed, and my own attempts at conversation were blunted by my preoccupation with the problem of finding a way out of this mess I'd created.

The damnable thing about it was that, barring some slip on Green's part, I couldn't think of a single way either to escape or to get the telepath shield away from him. And the more I thought about it the more I realized that we didn't even have the threat of official retribution to hold over his head if he flipped that switch—he could probably claim that I'd been so delighted with my new shield that I'd set up this little informal honeymoon trip with Colleen and that I'd dragged him along to take care of the electronics, which had unfortunately failed. With us gone it would basically be his word against Calvin's, and if Green had been smart he wouldn't have said anything to Calvin that actually involved the words *ransom* or *blackmail*. The bad thing about such a scenario was that, once he had what he wanted, Green might feel he had to kill us to maintain the charade.

Nelson had tried once to kill me. Now, it seemed, his ghost had given itself a second chance. I only wished Colleen hadn't been the means it had chosen—but, then again, her inclusion might have been deliberate. Nelson had hated all of us.

Sometime in the middle of the afternoon Colleen and I made love again, at her request, and for a while I was able to forget the danger we were in. Perhaps if I'd been paying closer attention to her I would have noticed the tension had left her muscles by then, leaving behind an almost unnatural calmness, and perhaps I would have wondered what that meant. Perhaps; but probably not. I'm not very good at reading physical cues.

Evening came, and Green again was too smart to leave us alone while he went for food. Apparently he'd become convinced that the police really hadn't been called in, and so he piled us into the car and we went out to a restaurant together. His new-found confidence went only so far, of course; the place he chose was a dark, intimate one with high-backed booths, where our chances of being recognized by anyone were minimal.

I'd expected dinner to be a strained affair; but while it was so for me the others seemed surprisingly relaxed. Colleen kept Green talking, both about himself and his ambitions. If I'd paid closer attention to the conversation I might have learned why succeeding with his mind reader project was so important to him. But my full attention was on the briefcase sitting upright on the seat next to him, and on the arm resting casually on top of it. Even when cutting his steak his left hand never moved far enough away from the switch for me to risk any action. I hardly tasted my own food, and felt almost resentful that Colleen so obviously enjoyed the expensive filet mignon she'd ordered.

The ride back to the cabin was quiet. Colleen huddled close to me the whole time, her hand stroking my thigh in a way more suggestive of fear and loneliness than of passion. Her friendly chatter in the restaurant, I guessed, must have been an act to put Green at ease, and now that I'd been unable to take advantage of the trick an emotional let-

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down was setting in. I wished that I hadn't been so quick to shoot down her suggestion that Rob might be able to gimmick together a telepath shield locater; at least that would have left her some small hope to cling to.

I parked out front as usual and we went into the cabin, Green with his damn briefcase keeping well back. Colleen turned on the light and we headed toward the bedroom; but as Green closed the cabin door behind us she touched my arm and stopped, turning to face him.

"Well, go on in," Green said, as I followed Colleen's lead and turned around. Green had stopped just inside the door, his expression more puzzled than wary. Not that he needed to worry; we were a good fifteen feet away from him, and even with the shield hanging loosely in his hand we both knew I couldn't possibly get to the switch before he did.

But Colleen didn't move. "No," she said calmly. "We can't let you continue with your plans, Ted. An electronic mind reader would bring chaos upon a world that already is sorely lacking in privacy—surely you recognize that. Do you care so little about other people that you would do something like this to them?"

"Oh, come on," he growled, clearly not in the mood for an argument. "You're blowing this way out of proportion. Only the wealthy and powerful are going to be able to afford mind readers—and they're only going to use them on each other. Besides, once I've sold enough mind readers I'll be marketing these telepath shields anyway. You'll have the status quo back before you know it."

I stared at him—the man was even more cold-bloodedly mercenary than I'd realized.

Colleen shook her head slowly, and for the first time I noticed her face was unnaturally pale. "No. We can't allow it."

"You can't stop me," Green said flatly.

"Yes, I can." Colleen paused, and I heard the faint sound of tires on gravel outside as one of the other campers returned for the evening . . . and without warning Colleen screamed.

It was a piercing, mind-curdling scream, so loud and so unexpected that for a second it literally locked my muscles in place. Across the room Green jerked violently, nearly dropping the briefcase; but before either of us could do anything more the scream cut off as abruptly as it had begun—

And Colleen was holding a knife hara-kiri fashion to her stomach.

For just an instant there was a deathly stillness in the room. I don't know how Green looked in that first second; my full disbelieving attention was riveted on Colleen. The knife, still greasy from the steak she'd been cutting with it half an hour previously, glinted with a horrible light from between her hands. Her eyes seemed black in contrast as they stared unblinkingly at Green.

"The game's over, one way or another," she said, her words soft and rapid, but with an iron cast to them. "You will set down that case and step away from it, or I will kill myself. I expect you understand."

With an effort I shifted my gaze to

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Green. He understood, all right; his face had gone a pasty white. If Colleen died before he could hit the switch his power over me would be gone . . . and I would kill him. "It won't work," he half croaked, half whispered. "You can't die fast enough. Your brain will live too long."

"Perhaps." Colleen's voice was still glacially calm. "But many people will have heard my scream, and some of them could be coming in the door at any time. You won't be able to pass our deaths off as strokes or heart attacks, not with a knife in me. And even if you manage to get away, you've left fingerprints all over this room." Outside, a car door slammed. "Here they come," Colleen said. "Decide, Ted. Now."

Green growled something deep in his throat, but I hardly heard him. Nausea was trying to turn my stomach inside out, and I fought desperately against the white spots forming before my eyes. But it was no use. The parallel was too close: Amos, too, had died of a self-inflicted knife wound in defense of someone else. The scene in front of me shimmered and faded . . . and the daymare began.

Amos, you're coming too close; it's beginning to hurt.

. I can't stop, Nelson. My plane's been hijacked.

You have *to stop. You* have *to! It hurts, it hurts.*

You're going to let her die, aren't you, Dale? She's going to die, just like Amos did.

No! I shouted, and even as I stood in the middle of it I felt the vision quiver. This wasn't the usual pattern . . . and with sudden clarity I saw that Nelson's death-wish within me had overreached itself. These were *Nelson's* memories, not mine, given to me in distorted form during our close approach five months ago. They had no basis of reality in my own mind to draw strength from. Illusions only . . . and with all the force I could gather I hit them with the strongest reality I had.

I AM DALE RAVENHALL! I screamed to Nelson's ghost.

And with a shudder the vision shattered.

I'd apparently been gone only a second or two, because the tableau was just as I'd left it. Running footsteps were audible outside, and Green half turned toward the door, his face contorted with indecision. His hand twitched—and I moved.

With my left hand I slapped Colleen's right elbow forward, knocking the knife point away from her body, and with my right I plucked the weapon from her loosened grip. Green looked back at the motion— and with a yelp ducked as I hurled the knife toward him with all my strength.

It bounced butt-end first off his shoulder, throwing him off-balance for a second. But it wasn't enough, and I wasn't more than a third of the way to him when his scrambling hand got to the switch. He froze for a single heartbeat, panic etched across his white face . . . and then he flipped it.

And nothing happened.

My charge ground to a halt as confusion slowed my muscles. The agony I'd expected—the red haze of pain as two minds crashed together—it simply wasn't there. I looked around, half afraid I was the only one unaffected, that I would see Colleen stretched on

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the floor in death; but she, too, merely looked bewildered. I turned back to Green, and as I did so the footsteps outside ceased and the door was unceremoniously slammed open. Two men charged in: Rob Peterson and a big blond man I'd never seen before . . . or rather, never seen except in photos.

"Are you two all right?" Gordy asked anxiously, looking back and forth between Colleen and me.

And finally I understood.

"It was plain dumb luck that we spotted you leaving that restaurant back in Moravia, or whatever that town was named," Gordy said, shaking his head. "We'd figured you to be a good five miles farther west, and when we cut through the edge of your shield I thought you'd passed us, heading for points unknown, and that we were going to have to start all over again. It's a good thing Rob recognized Green's car."

I nodded, feeling the tension drain slowly out through my arms as I held Colleen tightly to my side, and let my gaze wander. Green was sitting on the ground by Gordy's rented van; in the dim light streaming from the cabin's windows he looked like someone who'd just been condemned to purgatory. Rob, sitting cross-legged inside the van to take maximum advantage of the dome light, was doing a quick check of the wiring in Green's stolen telepath shield and fitting it with fresh batteries. And behind him, tied down securely in the van's cargo area, was the bulky shield Green had first demonstrated for me down in my basement. Chugging quietly beside it was the gasoline generator that supplied its power.

"Only two days," Colleen murmured. "It seemed much longer, somehow."

"To us, too," Gordy agreed. "If I never see another field of corn stubble I'll be perfectly happy."

I sighed. "Okay, I give up. You didn't just quarter the whole state until you found us, and I don't see anything that could possibly be a telepath shield locater in there. So how'd you do it?"

"With the best locaters you could possibly use for the job: two telepaths." Gordy glanced down at Green with what looked like rather cold satisfaction. "Green here made the mistake of telling Calvin that his gadget had a half-mile range, and once I got to Des Moines a little experimentation with the model he'd left behind showed us that the shield absorbs *all* telepathic signals trying to pass through it, whether or not the sender is actually within the field. By then Scott was in Chillicothe, so we had him stay put while Rob and I drove a hundred-mile-radius circle around him. We were just lucky that you'd gone to ground inside that range—we would have had to start all over again with a new circle otherwise."

"All set," Rob reported, hopping down from his perch and handing me the briefcase. "I've rewired around the switch, too, so don't worry about bumping it."

Gingerly, I took it. "What now?"

Gordy answered immediately; clearly, he'd already thought this through. "Rob and I will take Green away in his car while you drive Colleen back to Chillicothe in the van—you'll have both shields that way. I'll call Scott as soon as I'm clear here, so he'll be out of the

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way by the time you get there. After you drop her off, you can bring the van and shields back to Des Moines. I guess Rob or somebody will have to go retrieve your car later."

"Where will you be?" I asked him.

He hesitated, glancing at Green. "I'll be in the Dubuque area for a couple of days, I think," he said softly. "Even without access to Amos's devices Green knows too much about telepath shields. I don't think we should take the chance."

Beside me, I felt Colleen shiver. It had been done before, I knew; Nelson had used cult-style brainwashing techniques to condition the men who'd hijacked Amos's plane. With the insights and feedback telepathic contact permitted, the process wouldn't take Gordy more than three or four days. Looking at Green's grim expression, I realized then that he'd already figured out what we would have to do. I almost felt sorry for him, but decided to save my sympathy for Gordy instead. "I suppose you're right," I said. "Do whatever you have to."

The three of them left a few minutes later. Standing together by the van, Colleen and I watched their tail lights disappear among the trees. The sound of crunching gravel had been swallowed up by the rustling of leaves before she spoke. "We really don't have to leave here right away, you know," she pointed out. "Now that Green's gone, perhaps we could stay here for a few days."

"And try to repair the damage that's been done to my dreams?" I shook my head. "No. It's too late for that."

"I'm sorry." Her murmur was barely audible.

"Don't be," I said quickly. "It wasn't your fault. It's just that . . . we were like two cardboard cutouts in there. All of what makes you *you* was missing."

The words were hopelessly inadequate, and I knew it; but even as I groped for better ones I felt her nod. "I know," she said, and there was no mistaking the note of relief in her voice. "Your telepath shield made us normal people for two days . . . but we can't *be* normal people; not really. Maybe with enough time and effort we could learn some of the techniques, but it wouldn't be the same. I think perhaps we've been spoiled by our ability, even while taking it for granted. Even if the machines could somehow be made foolproof . . ." She shook her head.

"I understand." I sighed. "I'm sorry, Colleen—sorry for everything. It seems sometimes like everything I've done the past five months has gone wrong."

"Oh, I don't know," she said, attempting a light-hearted tone. "You saved my life a few minutes ago, when you took my knife away."

I snorted. "Even there I didn't have any choice. I couldn't let you die like that. It was how Amos died . . . how Nelson killed him."

She shuddered. "I guess we'd better go," she said, her voice dark again.

I nodded silently and we climbed into the van. It was strange, I thought, how dreams so seldom live up to their expectations. I'd wanted to be able to hold Colleen, to talk to her, and—*yes, admit it*—to make love to her. Now, all I could think about was getting a hundred miles away from her as fast as I could . . . so that we could be together again.

I was tired of being alone. ■

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Inventions Wanted

(Continued from page 10)

High Frontier? I'm not yet thoroughly familiar with its details, but my impression is that it may be a much better stopgap than we now have—*if* it's everything its proponents claim. Its key features, I'm told, include a point defense of U.S. missile silos and space-borne antimissile devices to destroy incoming missiles before they get close enough to hurt us. It has been described to me as a "shield" which cannot be used as an offensive or antipersonnel weapon system: "It can't be used to kill a single Russian." If all this is true, it sounds as if it might be a good thing to have around while waiting for real progress toward disarmament; at the very least, it sounds like a great improvement over MAD. But *is* it all true? Note carefully: I'm *not* saying it isn't, but only that any such proposal needs to be approached with skepticism, and instituted only after it has withstood close scrutiny. I recommend listening carefully to the High Frontier people—and making every effort to find holes in their arguments. If nobody can find any, then maybe we should go ahead with what they suggest—and we can then do so with much more confidence than we could without such an examination. These two questions seem crucial:

1. Can High Frontier really do all that is claimed for it? That is, is it really an effective shield?

2. Is it really *only* a shield? I will admit that I haven't yet thought of a way to use it as a very effective offensive weapon, but historically humans have been pretty clever about turning all kinds of things to offensive uses. Let's look at this one from the viewpoint of somebody who would like to use it that way—and also from that of a very clever enemy who would like to find a way through the shield.

Meanwhile, let's not lose sight of the larger goal. Disarmament is hard, but so are a lot of other worthwhile things. And even some big *social* problems have already been solved, at least in a shaky sort of way. Many of our ancestors would have found it very hard to believe that a whole population could be encouraged or even taught to read, that a country could be governed without a monarch, that an economy could function without slaves, or that women could vote. Disarmament may be the most important issue still on the agenda—the one that will buy time to work on the others.

The recent demonstrations here and abroad are significant not because they have solved the problem, but because they show enough people concerned about it, in enough places, that they just might be able to instigate some serious work on it, on a large enough scale to do some good. And once that work is truly underway, how far can it go? Conceivably, if the forces driving it remain diligent and determined long enough, to the abolition of war itself. The concept still sounds far-fetched to most people, because we have all heard so much about the history of violence; the accomplishments of nonviolent movements, *even against violent forces*, tend to be whispered (when they're men-

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tioned at all) in history books. But the abolition of war is a familiar idea to science fiction writers and readers. We've often talked about it as something that "advanced races" have done. The time has come to begin figuring out *how* they did it, so that we can do it ourselves. If we can do it, it will make our claim that *we* are an advanced race more credible.

If not . . .

What bothers me most about some military and defense industry people I've heard and talked to—and this is *not* a categorical generalization—is that they give me the disquieting feeling that they're actually rather fascinated with war and its machines. They seem uncomfortable with talk about peace, afraid that their playthings will be taken away from them if a real means to disarmament is found. They would never admit this, of course, probably even to themselves. They *say* they would love disarmament, if everybody verifiably did it, but it isn't feasible, and so the threats of enemy hardware must be countered by continual improvements in our own hardware. But their attitude suggests that their words don't tell the whole story. The people I'm talking about—and I repeat, I'm *not* talking about *everyone* in military or defense-related work—have not really examined any other possibilities. They have merely dismissed them.

But no one has ever solved a problem by dismissing it as insoluble. There are few problems that need solutions more than this one, and now is the time to get busy finding them. Hardware solutions, I predict, will never be more than stopgaps; *real* solutions will demand nothing less than those "social inventions" Fred Pohl talks about. (Though hardware and social inventions do interact, remember. The demise of slavery in the American South is largely traceable to Eli Whitney's invention of the cotton gin and interchangeable parts. Might High Frontier, or something like it, make nuclear weapons and their associated institutions obsolete? Might those very nuclear weapons even prove, ironically, to have been the invention which triggered the end of war itself, by finally scaring enough people into changing their attitudes?)

At this point, I would not presume to guess what form the required social inventions will take. Their seeds may already exist, perhaps in our first crude efforts at cooperative organizations of governments, or perhaps in the nonviolent movements of peoples *against* governments which succeeded where violence failed in such places as Norway, Denmark, or—many times—in India. The potentialities of those approaches have only begun to be explored, and there may be more fruitful avenues which we haven't even thought of yet. Nations themselves may, as some suggest, have outlived their usefulness.

Whatever the specific forms may turn out to be, it seems clear that not just hardware, but *social* inventions are necessary to achieve what has hitherto been too casually dismissed as a mere dream. To make it more than that, we need all the ideas we can get. Now. ■

● Progress is not an accident, but a necessity.
Herbert Spencer

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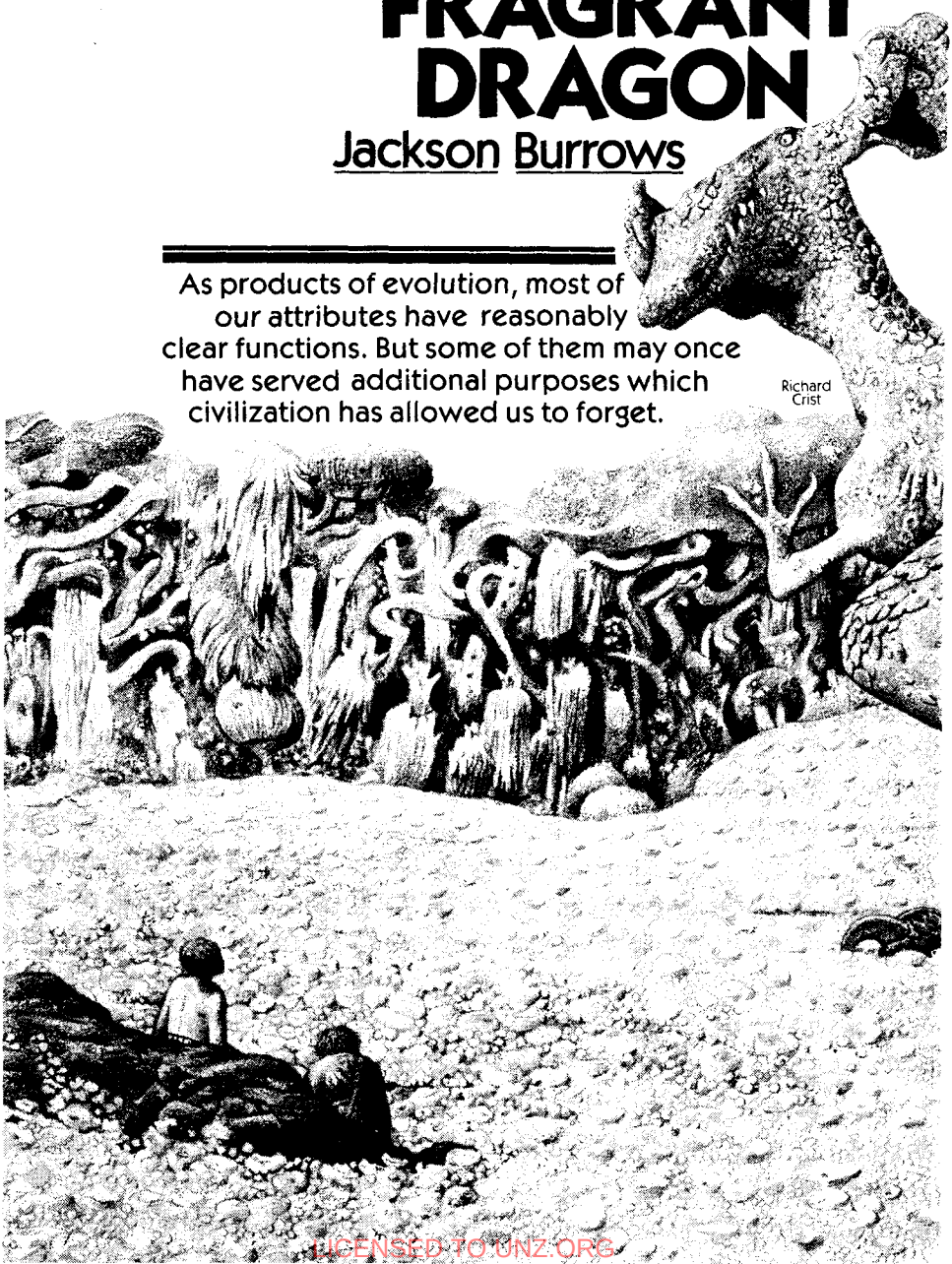
THE FRAGRANT DRAGON

Jackson Burrows

As products of evolution, most of our attributes have reasonably clear functions. But some of them may once have served additional purposes which civilization has allowed us to forget.



Richard Crist

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The two trapped spacemen called the beast a dragon. It looked not unlike *Tyrannosaurus rex,* except that it was twice as big and thrice as unfriendly. Its scales appeared to be at least as thick and tough as armor plate.

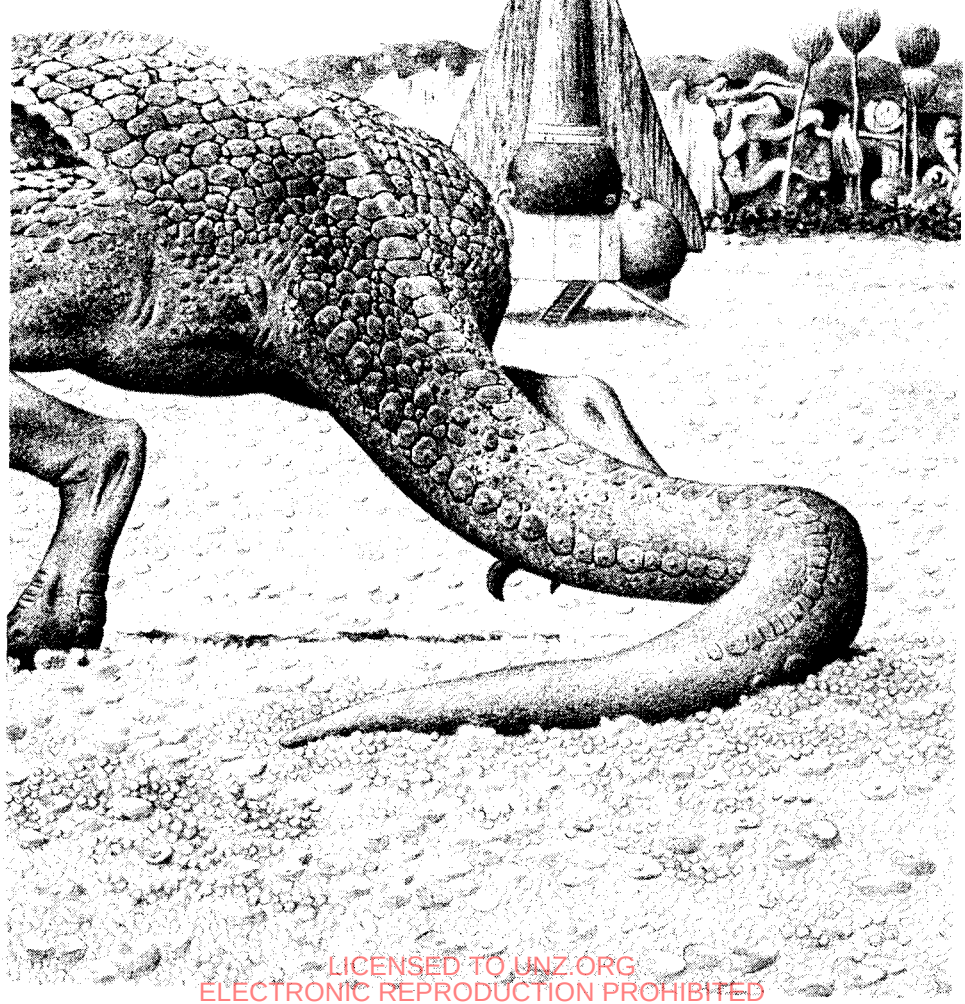
Right now the dragon was sitting back on its haunches, polishing off the last of the horse-sized animal it had caught only moments before. All that remained in the grip of the claws on the short front legs was one piece of white bone. The claws lifted the bone to razor-sharp teeth. There was a quick crunch, a quick swallow. Then claws and mouth were empty.

"Great galloping rockets," breathed Harl. "What do we do now?"

"We'll think of something," said Jahn. But for the life of him Jahn could not think of what.

The dragon sat in the pleasant flower-strewn forest glade, positioned exactly halfway between the two men and their spacecraft.

"So near and yet so far," sighed Harl.



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Jahn nodded. The ship couldn't be more than 200 yards away.

"It's the last time I volunteer for preliminary exploration of an uninhabited planet," Harl said.

Jahn eyed the dragon. "I wouldn't exactly say uninhabited."

"You know what I mean," snapped Harl.

Indeed Jahn did know what Harl meant. Jahn also knew something else—that Harl was badly frightened. Otherwise the man would not be talking so much. Well, Jahn was frightened himself. But he was expedition commander, and it was up to him to see that they both kept their heads.

"All we have to do," said Jahn slowly, "is stay calm. There hasn't been a beast born that a man can't outwit. And you've got to admit that we're in this jam because we were looking for excitement."

"Some excitement," grumbled Harl.

But Jahn was right: it was the promise of excitement that had brought the two to this impasse with the dragon. The boredom of regular spaceways patrol had gotten through to both of them. There had been fewer and fewer disabled spaceships in need of rescue, fewer and fewer pirate forays in need of repulse. Volunteering for the Planetary Exploration Corps had seemed the way to escape boredom.

So here they were, on a first assignment that had brought them to a planet so unknown that it still had only sector coordinates for a name.

The men had followed standard cautionary procedure before landing; sensor tests revealed a breathable atmosphere and no inputs of sentient hostility.

They put down at dawn in this pleasant forest glade with its carpet of red and white and yellow flowers.

Still they followed procedure. Regulations said one man must stay aboard ship at all times, manning the weapons that would cover the man who went outside to collect plant and soil samples.

Since Jahn and Harl were good friends, and since each itched to escape the close confines of the little exploration craft, they tossed a coin for the honor. Harl won.

"Beautiful!" he radioed to Jahn when he was halfway across the glade to the forest fringe. "You wouldn't believe the fragrance of these flowers. We can take back a growth stock and rejuvenate the galaxy's perfume industry! And even the forest is giving off a wonderful sachet, like fallen pine needles under a hot sun, only twice as aromatic."

Jahn smiled at his companion's enthusiasm. "Sounds like Eden," he replied. Nevertheless, he kept the ship's laser guns at the ready. And he had one eye on the hostility sensor.

"I'll circle the glade, taking my samples, and then maybe I'll try the forest," Harl said.

"Better not go into—"

"Just the fringe. I'll stay in sight."

Before Jahn could protest again a violent rumbling shook the ship. Still the hostility sensor showed no danger. An earthquake?

"Harl! Get back here!"

Too late the sensor sprang to life. Something massive and hostile, hostile, hostile was sweeping out of the forest on the side away from Harl. It plunged toward the space ship.

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"Harl! Take cover! I'll pivot these guns—"

Again too late. The view screen showed a giant scaly something bearing down on the ship. It rammed into the craft, bounced off, and rammed again. Jahn swung wildly in his gunner's harness. Again the ramming. Then all of the craft's sensors went dead.

Jahn, if he fired, would fire blind. And Harl might be in the line of fire.

All at once the ramming stopped. Jahn guessed—correctly, as it turned out—that the scaly behemoth had caught sight of Harl and was turning its attentions on him.

Standard procedure said that Jahn should stick with the ship.

"The hell with that," growled Jahn, strapping on a hand laser. Harl was in danger, and he would never be rescued by a man who stayed inside a blinded spacecraft.

Jahn activated the airlock, praying the door hadn't been jammed by the battering.

The door inched open.

Harl was nowhere to be seen, but the beast was sitting on its haunches between the ship and Harl's last known position. The great scaled head was bent a little to one side; the creature was studying a laser pistol that it held in its two front claws. Harl's pistol.

Even as Jahn's eyes searched desperately for some sign of Harl, he was aware that from everywhere there flooded into his nostrils the gloriously heady perfume of flower and forest. He fought off the almost anesthetic effect and carefully aimed his laser at the beast's head.

But just then one of the monster's talons touched the trigger of Harl's weapon. A blinding beam of death lanced out and nicked a giant ear. The beast bounded off into the forest, a raw high shriek of pain echoing in its wake.

Jahn scrambled toward the spot where he had last glimpsed Harl.

"Over here!" Harl's cry came from a little overhang of rock at the forest's edge.

"Quick! Under the ledge!" Harl shouted. He rose from the cover of the overhang and dragged Jahn back into the hiding place with him.

The beast, its attention drawn by Harl's calls, dashed back into the glade. It paused, sniffed the air, snorted once, and then raced toward them at a speed incredible in such a monstrous hulk.

Still Harl dragged at Jahn. "Farther back!" Harl hissed.

Jahn saw that there was a small dead-end cave under the overhang.

Harl dragged Jahn back into the cave, and around a corner into a little rocky alcove.

The thundering approach of the beast became an earthquake. Pebbles cascaded down from the alcove's walls.

There was a sudden silence, and Jahn could not tell what the beast was doing. Then an aroma more fragrant than that of the flowers swept over him.

"It's the dragon's breath!" whispered Harl, perspiration popping out on his forehead. "I smelled it when he first attacked me in the glade."

"Dragon, eh?" breathed Jahn.

"Yes. And that sweet smell means he's sniffing around the overhang looking for us. Thank God he's too big to get into the cave."

But then one of the monster's short upper arms reached blindly in, talons

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scrabbling at the rocky walls. A talon got as far as the entrance to the alcove. From this close it looked like a giant's cruelly curved scimitar.

Jahn, his back pressed hard against the farthest wall of the alcove, unlimbered his laser gun.

"This will teach our friend a lesson," he gritted, aiming at the talon. He took careful aim and squeezed the trigger.

Nothing happened. Jahn squeezed again. Still nothing.

Appalled, he stared at Harl while the talon scrabbled on.

"The amplifier!" moaned Jahn. "I forgot to inject the amplifier."

Standard safety procedure required that all sidearms aboard a ship be empty of amplifiers until put to use. Jahn had overlooked this fact in his pell-mell attempt to rescue Harl.

The talons scrabbled some more. One caught on Jahn's shirt, ripped it off. But that was apparently as far as the beast could reach. The talons, Jahn's shirt tangled in them, withdrew.

Jahn turned to Harl. "Maybe we can recover your laser. Surely the dragon dropped it when he took that nick in his ear and retreated into the forest."

Harl wasn't listening. "You forgot the amplifier," he said in accusation. "And you didn't detect the dragon's hostile presence until too late."

Jahn sensed the near-panic in the other's voice. "So I forgot the amplifier," he said softly. "For that matter, the rules say I should have stayed with the ship. My only excuse for both failings is fear for your life. And as for detecting hostile sentience—well, the sensor didn't work until too late. I suspect faulty calibration. We'll know when we get back to the ship."

"If we get back," snapped Harl.

Jahn clenched his teeth. He had not really known Harl until these last few minutes. Harl was the younger and less experienced of the two, but both had been trained to handle themselves in tight spots. Somehow the training hadn't taken with Harl, and no one had known it until this moment. Perhaps not even Harl. It just made Jahn's job that much tougher. He made one more attempt at peace and rationality.

"Harl, I made two mistakes. I've admitted them. But this is no time to place blame. This is time to concede

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that to err is human, but also to know that to be human is also to know how to get ourselves out of this mess."

Jahn edged out of the alcove and crept through the cave to the overhang outside. The dragon, the space ship, the flowers. All were visible. The hand laser was not. It had to be out there, lost under the flowers. Jahn wondered how long it would take to find it, even with a metal detector and without a dragon.

Harl, grudgingly edging out behind him, guessed his thoughts. "We'll never find that gun," he said, "not with the time the dragon's likely to give us."

"How did the dragon ever get hold of the gun, anyway?" Jahn asked.

"After he attacked the spaceship he came after me. I lifted my arm to shoot. The gun must have glinted in the sunlight. The dragon went after the glint instead of me." He paused. Then: "I suppose you're going to blame me for losing my weapon."

"Not at all," said Jahn smoothly. "I just wanted to know what happened. And I'm glad you've told me. It gives me an idea. Maybe I could distract the dragon's attention with my laser, the same way you did with yours. I could creep out as near to him as I could without detection, then give the gun a heave toward the forest. It will glint in the sun like yours did, and the dragon will pursue it. That's when we make a dash for the ship."

Harl looked dubious. "It might be better to wait it out. The dragon can't stay here forever. A giant like that must have to go on almost a constant prowl to fill his belly."

Jahn recognized wishful thinking when he heard it, but at the same time Harl might have a point.

As if to give lie to the thought, another horse-sized creature appeared at the edge of the glade. It was four-legged and, with its light coat of fur, appeared mammalian. It stepped daintily among the flowers, munching petals.

"Not very bright," murmured Jahn. Or was it just poor eyesight?

No matter; its doom was sealed. The dragon made one giant leap, grasped the animal in its talons, and had it downed, bone and all, within seconds.

Perspiration, raw and cold, wreathed Jahn.

"Let's wait him out," said Harl again. He wiped perspiration off his own brow.

Jahn realized it was not only the dragon that made them perspire. The sun was high now, and the day grown hot and humid.

"We might wait a little while," Jahn conceded. "We don't know how bright that monster is. Maybe he'll forget all about us and wander away."

The creature, licking its talons, swung its head back toward the overhang. The two men shrank from the beady, unblinking stare.

"Oh, oh," said Jahn. "Scratch forgetfulness."

"I still vote for waiting," persisted Harl. "At least until dark. I'll bet the dragon doesn't see any better than we do at night. We can probably sneak past it."

Jahn could have pointed out that they knew nothing about the creature's eyesight, good or bad, night or day. But he held his tongue. There was no way, in this position, to fight rationalization

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rooted in fear. Harl, purely and simply, did not want to leave their place of refuge.

For another hour the two men crouched there under the overhang. The day grew hotter still, and Jahn, wiping his brow, finally said what he knew Harl would not say.

"We have no food or water," he said. "We can go a long time without food, but not without water. Not in this heat." He could feel the perspiration dripping down his sides.

Still the dragon made no move to leave. It sat out there in command of the glade, its great head swinging from side to side. Two more times horse-sized animals drifted from the forest into the flowers, and two more times the dragon made short work of them as they grazed.

"At least he's leaving the space ship alone," mused Jahn. "He must have smelled your presence in the glade and mine in the ship. The ship was closer to him than you, and so he attacked the ship first. Then he went after you. Now that we're not aboard he has no interest in the ship."

Harl remained silent.

"That means we're going to have to lift off awfully fast once we're aboard," continued Jahn. "The dragon will come after us then, and I don't know how much more ramming the ship can take."

The dragon suddenly loosed a strangled cry, half trumpet of elephant, half hiss of snake. Out of the forest plunged another creature just like it.

"Oh, no!" groaned Harl. "We'll never get past two of them!"

"I'm not so sure we'll have to," said Jahn, peering into the glade. The two beasts were circling each other, boxers in a ring.

The challenger was a shade smaller than the challenged; the lighter color of its scales suggested it was younger.

The smaller beast plunged forward, razor teeth bared in a drive toward the other's throat. Its opponent responded in turn, and for the next few minutes the glade shook and thundered with their combat. The great bodies, locked together, heaved and rolled across the earth like moving mountains.

"The ship!" growled Jahn. "Stay away from the ship!"

The beasts hissed and thrashed, screamed and clawed.

"Think we should try an end run through the forest?" Jahn asked. He had only to look at Harl's fear-frozen face to know his companion's answer.

But, even had Harl been willing, there was no time to make a run for it. The savage battle ended as quickly as it had begun. The challenger, bleeding in a dozen places, broke off the fight and reeled back into the forest. The sound of its retreat trailed off into silence as it put distance between itself and the glade.

"So that's it," said Jahn.

"Eh?"

"These dragons don't live in the forest; they live in the glades. Each has its own glade, its own turf. The way to get yourself a glade is to take it away from another dragon."

"But why restrict yourself to a glade? Why not roam the forest?"

"Those trees are closely packed. When you're just about the biggest, toughest, fastest thing in sight, why restrict yourself? Chase a little horse-sized

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animal in the forest, and it will have a pretty good chance of getting away while you're blundering into tree after tree. Besides, the little animals are very accommodating; just sit still in your glade and they will come to you. The dragon, after all, is a form of life, and like most forms of life it has learned to take the easiest route to survival."

"Then that means there's no chance of the dragon wandering off and giving us a chance to get back to the ship."

"Yes, Harl, but it also means something else. It means that we might have a chance. If we could cross the little open space between here and the forest, and then circle around through the trees to the other side of the glade . . . "

"But even if we made the forest from here, we'd still have to re-enter the glade to reach the spaceship."

Harl was right, of course. Jahn had just let himself do a little day-dreaming.

The afternoon wore on, hot, humid, flower-fragrant.

"What we need is a weapon," said Jahn.

"But what?" asked Harl. "We haven't even got a knife, let alone a working laser or a stun gun."

"We have our minds," said Jahn. "We are men. We are of a race that rules the known galaxy. We will not knuckle under to that big ravening pile of tooth and claw."

"There are rocks in the cave," said Harl ironically. "What shall we do, stand up and throw rocks at the creature? Somehow make slingshots from our clothes and emulate David quelling Goliath?"

Once more the dragon pounced and fed upon one of the horse-sized animals. Then, as though the animal had only been an appetizer, the dragon again turned its attention on the spacemen. They responded to the thunderous approach by retreating to the little alcove.

But this time there were no questing talons, no aroma of dragon breath. There was only sudden silence as the dragon stopped short just beyond the overhang. Then came the rumble of the beast's return to the center of the glade.

"Now why didn't it attack this time?" mused Jahn.

"Who knows," grumbled Harl, more in statement than question.

"It could be important," pursued Jahn.

"In what way?"

Jahn smiled wryly. "As you say, who knows?"

Nightfall brought little let-up from the heat. The two spacemen, thirsty and hungry, lay for a while under the overhang, watching the silhouette of the dragon against the star-flooded sky. Finally they crawled back into the alcove in search of sleep.

Jahn drifted into troubled slumber, the fragrance of flowers in his nostrils, the cold of perspiration on his flesh.

Once he awoke. He could not tell whether it was minutes or hours later. He had been dreaming. The dream was discordant and fragmentary. In one portion of it Jahn was riding the newest and finest of starships, marveling at man and his technology. But in another portion, clad only in an animal's pelt, Jahn had been swinging a wooden club and shouting derisively as a saber-toothed tiger slunk away from him. Somehow he was both men, the master of technology and

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the savage in the jungle. More importantly, somehow it was necessary that he be both men.

When next Jahn opened his eyes, pale light was filtering into the alcove, and he could make out Harl's body huddled in sleep beside him in the cramped confines of the alcove. It must have been full dawn outside.

Once more the ground shook and thundered. Jahn crept back to the overhang, an awakened Harl behind him. They peered out into the sunlit glade in time to see the dragon down a last blood-spattered bone.

Jahn's mind went back to an earlier thought. He hefted his useless laser in his hand. "Now that the sun's up, I might just heave this thing as far as I can. If it catches the light, and the dragon goes for it, we dash for the ship."

"We'd never make it," said Harl. "That beast is just too fast."

"But if it went after the gun, and took a minute to find it, and another minute to examine it . . ."

"The ship is 200 yards away," said Harl grimly.

"I'm going to try it," said Jahn. "Another day in this heat will leave us too weak to walk, let alone run."

"It won't work."

Jahn, on his belly, edged out from under the overhang. "Harl, you just be ready to run," he gritted.

When he was less than ten feet out into the flowers the dragon swung an inquiring muzzle toward him. "Now!" he shouted, flinging the gun as far as he could to his left. The weapon arced up, spinning and shining in the sun.

The dragon bounded up from its haunches—and made a beeline for Jahn. The two men barely got back into the alcove before the monster thumped to a stop outside. But, for the second inexplicable time, no taloned forearm probed the cave. A moment later the men heard the beast rumble back to its central position in the glade.

"It gets curiouser and curiouser," murmured Jahn.

"What? The dragon?"

"No. The situation."

"I don't see anything curious about it."

"Why didn't the dragon reach in and try to grab us?"

"He tried it once," said Harl. "It didn't work. So now he knows better."

"But it almost worked," said Jahn. "He got my shirt, didn't he? You'd think that would be incentive enough for another try or two. But twice now the dragon has stopped short of the overhang and—well, actually retreated."

Harl snorted. "Retreated? That thing? It doesn't retreat from anything, not even its own kind. You saw that battle yesterday."

Jahn crept back to the overhang, musing. Harl was right. The dragon didn't retreat from anything. But it would not reach into a cave to capture two puny men.

Unbidden, there came to Jahn's mind the image of an all-but-naked cave man brandishing a club, and of a saber-toothed tiger slinking away. There was something about the image. . . .

"A club!" breathed Jahn. "We need a club!"

Harl stared at him in speechless horror, as though Jahn had gone mad.

"Don't you see?" husked Jahn.

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"Earlier, I said we needed a weapon. I said man rules the known galaxy because there hasn't been a beast born that can outwit him. So we are men, and now I have used my mind, and I have found a weapon."

"But—a *club?*—against a *dragon?*"

"Exactly. There must be a fallen branch somewhere close by. Help me find it."

But Harl just crouched there, staring at Jahn in frozen fear. "You've gone crazy."

Jahn laughed. "Not at all. I should have thought of it sooner, only I'm too civilized. And by 'too civilized' I mean there are too many generations of technology behind me, so many that I almost forgot a fundamental." He brushed the perspiration from his eyes and grasped Harl's shoulder. "Man, don't you see? The fragrance of flowers and forest, of the dragon's breath? And the heat; don't forget the heat!"

Harl rocked back on his heels. "You *are* crazy," he hissed.

Jahn grinned widely. He was really starting to feel quite good about things. "I'll find that fallen branch. Meantime, take off your shirt."

Jahn, crawling, found a suitable branch among the flowers a scant five feet beyond the overhang. He dragged it back with him—to the accompaniment of pounding dragon charge. He and Harl dashed into the alcove. But for a third time the dragon did not try to ferret them out.

Jahn inched back to the overhang to retrieve his branch. It was about as thick as a man's upper arm, almost straight, and perhaps four feet long.

"*That's* a club?" breathed Harl.

"Sure. It was probably torn down and blown into the glade during a storm. No matter; it's not too rotten."

"Not *too* rotten?"

"No. It'll do nicely."

Again the earth trembled to dragon charge as another horse-sized animal was caught and instantly devoured.

Then Jahn told Harl exactly what he planned to do, and why.

"It's our one and only chance," Jahn concluded. "We must do it."

"But if you're wrong—"

"If I'm wrong, then we'll go down the dragon's gullet, but given all the facts, I don't see how I can be wrong. Anyway, a pretty prompt death from thirst is our only alternative. And, as they say, I would rather die like a man than a rat in a trap."

Harl thought about it, and at last Jahn saw a straightening of his shoulders. There was a long pause. Then:

"You're right," said Harl. "I never did like rats." And Jahn knew that at last Harl had mastered his fear. Now if he could just keep it in check during the perilous confrontation with the dragon . . . why, then Harl would have fear mastered for the rest of his life.

Silently Harl stripped off his shirt and handed it to Jahn. Jahn tied it by the sleeves to one end of the branch, then picked up the branch by the other end.

"Ready?"

"Ready!"

Jahn notched the branch into his belt and lifted it to a forty-five-degree angle. Harl's shirt drooped from the end, a listless flag in the shimmering heat.

"Now!" ordered Jahn, not caring if his voice attracted the dragon. He stepped boldly out into the glade, Harl in lock-

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step right behind him. "Stay close!" Jahn warned.

The dragon plunged toward them. The forearms reached down, the head snaked in.

"Come and get it!" shouted Jahn, waving the shirt in front of the beast.

The dragon whooshed in surprise, turned tail, and pounded off to a side of the glade.

"Keep going," Jahn cautioned. "He may come back for one more try."

The dragon circled them warily, then roared in.

Up went the shirt, but this time the razor teeth closed on the branch, snapping it. The shirt lodged in the teeth.

Again the dragon retreated, tearing at the shirt with its talons, shaking its head drunkenly.

"That should do it!" exulted Jahn. "Now we will continue to walk, not run, to the nearest spaceship."

"Why not run?"

"Because we don't want that dragon, dullard that it is, to forget who we are—and what we represent. If we run, it might get confused and think we're local prey. I'd hate to get snapped up before it discovered its mistake."

"But it would discover the mistake?"

"Oh, yes. And spit us right out. But by then we'd be dead."

"I never thought of perspiration as being a survival mechanism," said Harl.

"Nor did I. As I indicated, we're too civilized. To us, perspiration is undesirable, something to be whisked away with baths and deodorants. But I wonder how many cave men it saved from saber-toothed tigers?"

"Definitely a survival mechanism," agreed Harl.

"Sure. Most mammals—at least those that live on land—pant to adjust their body temperatures when they get too hot. But not man. Man perspires. And when he is trapped for a day and a half in a most warm and humid climate, he really perspires. And then the bacteria get to work on the perspiration. And then, of course, man stinks to high heaven."

"And on this planet," said Harl, "on this planet, where flowers and forest and even a dragon's breath are extraordinarily fragrant—"

"Right," said Jahn. "On this planet a man stinks to higher heaven. I should have guessed after the dragon snagged my shirt in the cave. That shirt smelled bad to him. Then, after a period of time, he attacked us a few more times. By then I guess we were really stinking up the place. We must have smelled like carrion to our friend. That's why he broke off the attacks and never tried to reach into the cave again."

"But between attacks he forgot," said Harl. "It took the smell of us, close up, to remind him."

The two men arrived at the base of the ship.

"I guess we've made it," said Jahn, looking back at the dragon sitting on its haunches in the center of the glade.

"No sweat," said Harl. ■

● If you cannot get rid of the family skeleton, you may as well make it dance.

George Bernard Shaw, *Selected Prose*

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the reference library

By Tom Easton

My Brother's Keeper, C. Sheffield, Ace, $?, 216 pp.
Starburst, F. Pohl, Del Rey, $12.50, 224 pp.
Eyas, C. Killian, Bantam, $2.50, ? pp.
Murdercon, R. Purtill, Doubleday, $10.95, 181 pp.
The Last Yggdrasill, R. F. Young, Del Rey, $1.95, 135 pp.
Under Heaven's Bridge, M. Bishop & I. Watson, Ace, $2.50, 198 pp.
Ryn, J. Wodhams, Void, A$3.95, 196 pp.
Satyrday, S. Bauer, Berkley, $5.95, 211 pp.
The Business of Being A Writer, S. Goldin & K. Sky, Harper & Row, $13.95, 321 + xiv pp.
Fantasy Voices 1, J. M. Elliot, Borgo Press, $2.95, 64 pp.
Masters of Science Fiction 1: Essays on Six Science Fiction Authors, B. M. Stableford, Borgo Press, $2.95, 64 pp.
Science Fiction Voices #4, J. M. Elliot, Borgo Press, $2.95, 64 pp.
Science Fiction Voices #5, D. Schweitzer, Borgo Press, $2.95, 64 pp.
Great Issues of the Day 1: The Future of the Space Program, Large Corporations, & Society, J. M. Elliot, Borgo Press, $2.95, 64 pp.
Science Fiction Westerns Vol. 1: Wilderness Visions, D. Mogen, Borgo Press, $2.95, 64 pp.
Science Fiction Writers, E. F. Bleiler, ed., Scribners, $55.00, 623 + xvi pp.

This month I get to start off with three very nice books. They are quite different sorts of things, and one might expect them to appeal to different sorts of people, but they all appeal to me. And I recommend them all to you.

The first is Charles Sheffield's **My Brother's Keeper.** The gimmick is nifty, and maybe even possible. Twin brothers crash in a sabotaged helicopter. Neither is killed outright, but both are badly damaged, especially in the head, and near death. Fortunately, medicine is now capable of making nerves regenerate, and a hotshot surgeon is nearby.

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From the two mangled brothers, he rebuilds one. The survivor is mainly Lionel, a pianist, but his brain now contains a chunk taken from Leo, a secret agent. This chunk contains a large part of Leo's memories and even of his personality and, as Lionel recuperates, those memories begin to surface. They drive Lionel to pursue the mystery of Leo's past activities and assume his mission, to keep a new technology of body control out of the hands of organized crime. They lead him around the world and in and out of trouble until the finale. He confronts a sadistic dragon-lady, faces Leo's child bride, and comes to accept that he can no longer play the piano as he once did.

Lionel is a well-realized character. A very few others, such as the jazz-pianist yegg, are too. Most are no more rounded than they need be for their roles. We don't really object, for *Keeper* is not intended as more than entertainment, and there is plenty more to earn our attention. The style is smooth and competent, as we expect from Sheffield, with many nice touches. It is more as well, for I found the story reminiscent of Dick Francis's tales, and that is a strong recommendation. I think I may be so reminded partly because of the hero's abuse, but there is more, too. As the hero narrates, he displays a remarkable self-possession despite all past ordeals and future prospects. He shows none of the panicked flailing so common in the American suspense story. *Keeper* thus has a certain British flavor.

The second goody is Fred Pohl's **Starburst,** a tale of superscience told at least partly tongue in cheek. Dieter von Knefhausen, who as a boy gamboled with Hitler's Youth, is the president's science advisor at a time when the world is crumbling. The citizens are rioting. International tensions are taut. The end of the world seems at hand. To save all, he conceives a grand project: Send a crew of genius astronauts to colonize the planet of Alpha Centauri. To amuse themselves on the way, they will develop their minds, solve all the problems that make life on Earth so tenuous, and radio their answers back home. At first, only dirty Dieter knows Alpha Centauri has no planets and that his astronauts are doomed. He thinks the astronauts' lives a cheap price for salvation. Others do not agree when the secret gets out, rather sooner than Dieter had hoped.

The astronauts develop pretty much as planned. They begin by tinkering with the pills given them to control their sex drives and devising a true mind-expander. They then solve puzzle after puzzle in math, physics, and biology. One dies in an experiment and becomes a ghost. The rest become psychic gene manipulators, far-seers, and planet builders. They have kids in litters, who mature at four. They arrive, build their own world, loose a vengeful blast of radiation that wrecks Earth's civilization by melting down all radioactives, and eventually mount a return expedition to rescue the savages. But though they have in fact found the solutions Dieter wished for, they are no justification of the old saw, "the end justifies the means." Pohl's final point has to do with the worth of externally imposed solutions. That vengeful blast created chaos, but from the chaos has emerged at least one group of remarkable maturity.

Pohl strains the reader's credulity at times, but he keeps the pace fast and the interest up. *Starburst* is a pleasure to read, and the end is rather more satisfying than we often see—or, for that matter, than we expect this time.

* * *

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The third goody is Crawford Killian's **Eyas.** Much better than Killian's earlier *Icequake*, it is set ten million years in Earth's future, when the land bears different shapes, old species have vanished and new ones, some made, have appeared, and the dead rule the living with an iron hand. In the Gulf of Islands live the People, a race of human fishers who thrive under the tutelage of a whale-like Goddess. Over the mountains live the human Suns, ambitious to rule the world. Overhead float the nonhuman windwalkers, buoyed by hydrogen-filled seedpods. North live centaurs. East are lotors.

To the Gulf come two Sunnish ships. The pursued crashes; from it are saved a woman, a boy and heir, and an infant. (The fishers later destroy the pursuer.) The Goddess names the infant Eyas, hawk fledgling; nurses him briefly, and gives him powers. In time Eyas and the boy, Brightspear, grow up. Brightspear turns evil and leaves to conquer the Suns. He returns to destroy the People. Eyas flees with his centaur friend, Boulder, and raises an army to counter Brightspear. He succeeds, and in the process he grows from fledgling to a hawk that can harrow Hell itself. His maturity is not when and what it first seems within the tale.

So much is synopsis. It is not the tale itself, and if it makes the tale sound like a fantasy, do not be deceived. It certainly has its fantasy elements, but they receive an SF rationale at the end, and one that for the most part satisfies. I won't reveal it, but I will urge you not to let the book's blurb—"The magnificent saga of the twilight of man"—fool you. When you finish the story, I think you will see that the saga remains untold, and *Eyas* really recounts the dawn, after eons of night.

The story is strong in plot, action, and drama. However, the strongest reason for reading it may be its richness of detail, of the incident of living, of environment and sensation, though much is implicit. I found it an absorbing game to seek the similarities and differences between our own world and Killian's. Rabbits exist, as longears, but not deer. Birds are rare, their places taken by descendants of bats or lizards. Spiders are cat-sized and bright. And more. Given a history of human environmental degradation, recreation, and creation over ten thousand millennia, the pattern of Killian's world makes satisfying sense.

For a change of pace, how about a lemon? I hold up for your reviling Richard Purtill's **Murdercon.** What is it? It's Asimov's *Murder at the ABA* rewritten for SF. It's got the con furniture. It's got in-jokes. It's great fun for the fans. But is it any good?

No. It's obsessive in its attention to irrelevant minutia. It's labored. And it's obvious. You see the answer to the mystery immediately. The only question remaining is how, and the answer to that isn't much of a thrill.

Murdercon is eminently forgettable. So forget it already.

Better is Robert F. Young's short **The Last Yggdrasill.** Once upon a time, the last survivors of a strange species found a world and settled there, as giant trees. They knitted themselves into the world's ecology until even the local sentients became dependent on them. But in time the sentients became "sophisticated" and forsook as superstition those aspects of their lives that supported the trees. The trees died, all but one, and so did the sentients.

Then came Man, full of refound arrogance, to farm the world, to damn the last surviving Yggdrasill as a source of

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damp and houserot. Then came the Treeco crew, interstellar tree surgeons, to remove the tree.

All goes well, except that the tree-feller, Tom Strong, meets and loves the tree's dryad spirit. Except that one of Tom's past loves, a rejecting round-heels with a weakness for cads, shows up as a newscaster. Except that the tree falls, all 1,041 feet of it, piecemeal.

It's not a long story. Nor is it a heavy one. It seems an unambitious bit of entertainment. But there are parallels as well as conflicts between Tom and the dryad. Young has drawn a metaphoric comparison of human love with ecology that enters your thoughts only after you have finished the book, when you are later reflecting back upon it. He is not obvious. Nor is he impenetrably subtle. The effect is delayed largely because Young puts his story first. The meaning is implicit, not explicit, and it is a worthy meaning.

I enjoyed the book. Go thou and do likewise.

The message of Michael Bishop and Ian Watson, in **Under Heaven's Bridge,** is more heavy-handed than Young's. A crew of researchers is visiting the world of the Kybers, so named because they seem an odd blend of flesh and metal. The narrator is the Japanese linguist, Keiko Takahishi. Why Japanese? Apparently solely so she can remember Kyoto's Sanjusangendo, the Buddhist Hall of Mercy with its thousand statuary avatars of Kannon, god of Mercy and Compassion. The statues, you see, bear spiky halos like the Kybers.

The halos are the story's frame. Keiko and her fellows teach the Kybers their language and begin to talk with them. They learn the Kybers' sun will soon go nova, and they try to talk a few Kybers into leaving with them. Yet the Kybers seem reluctant, confident that they can cope. The reason for the confidence emerges as the pattern of the Kybers' reproductive cycle becomes clear. Breeding is a rare event, timed to anticipate great environmental changes, and it is used to remodel the species to meet the new demands upon it. The Kybers can, perhaps, survive even a nova.

Yet a few Kybers do leave their home for Earth, locked in a trance-like death-sleep. On Earth, they are exhibited like statues in museums and elsewhere, and one comes to rest in the Hall of Mercy. When Keiko, many years later, visits it, she detects a promise of awakening, of Kannon's return, of salvation for Earth.

I give away too much, don't I? But anything less would be a cheat of a review, like describing "Washington Crossing the Delaware" as a painting of a bunch of men in a boat. It would miss the point. And the point is so much the story that the story would not exist without it.

I might add that the heavy-handedness seems to be much more Watson's game than Bishop's. He often seems deeply concerned with apotheosis and salvation, with humans vs. gods, and he has done it better before. Bishop more often deals with the individual vs. herself, and he too seems to work better alone. This may be a case of a collaboration that just didn't work well.

Void continues to maintain its commitment to native Australian SF. I've got three novels in the stack this month, but I've only read one so far—Jack Wodhams's **Ryn.** The title is strange enough. The cover art is stranger. And there's no blurb to help. So—you really do need a few words of warning in case you ever see the book.

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Ryn is a name. It's the name of an infant, no ordinary infant. And it is a plight. Ryn, you see, isn't the blank slate his parents so fondly believe him. Shortly before birth, he came to awareness as Gabriel Benhusa Manakwa, an African coloured residing in England. Gabe's last memory is of entering the hospital for a bypass operation at age 62. His first sense of his new incarnation is struggling like mad to escape a rubbery bag.

At first, Ryn/Gabe seems retarded. He's confused, naturally enough. But he catches on before long and then begins to appreciate the unique powerlessness of the infant. He is frustrated beyond belief (I suspect Wodhams is guilty of understatement!), but rather than reveal himself as a precocious genius and freak, he hides his possession of a 62-year-old persona, allowing himself the outlet only of clandestine long-distance phone calls.

Inevitably, he is caught. What happens then, I won't reveal except to say it's fairly understandable, and it leads directly into the story's closing framepiece.

The story is nifty, a genuine "What if . . . ?" and very possibly one of the best available examples of an SF writer imagining himself into another being's skin. Yet I suspect it would not be publishable in this country. Editors would call it too unlikely, or too cute, or too unjustified, or . . . whatever. It is very much to Void's credit that they published it. I do wish they would find a U.S. distributor and give you all a chance to sample their wares without having to write to Australia for them (Void's address is: Cory and Collins, P.O. Box 66, St. Kilda, Victoria 3182, Australia). Or do the SF bookstores hither and yon carry Void's wares? Would anyone who knows of a U.S. outlet for Void please let me know? I'll pass the word on here.

Steven Bauer's **Satyrday** is, as billed, a fable. A wicked old owl, with the aid of a flock of raven henchmen, steals and imprisons the moon. He knows the sun will pine and fade for the loss of her sister, and then night will cover all, forever. He will rule the world.

But the apostate raven, Deirdre, flies to tell the only human alive and free. He is a boy, Derin, cared for by the satyr Matthew. They go to the moon's rescue with the aid of a white fox who can change shape to mermaid or nymph. And, of course, they succeed.

Bauer is working in an old, old vein, familiar to us all from our readings of mythology. It is rather more detailed than anything in Bulfinch, though, and it has a fairly modern flavor, a prosaicness and distance that despite an abundance of charm, despite Bauer's keen eye and ear, utterly spoil it. It is by no means comparable to *Watership Down*, which successfully gave its readers a sense of how a rabbit might feel, and if it resembles *Pinocchio* or *Snow White*, it is in their Disney versions.

Well, not quite. Bauer *is* considerably more bloody-minded than Disney ever dares. But he *does* get insufferably cute, and if I dasn't call the book a lemon, that's only because I can too easily see how it might appeal to many readers. Bauer's a poet, you see, and his work has the feel, if not the substance, of "literature."

I know some of you out there are writers. Some of the rest of you dream of becoming writers. The remainder — well, I'm not at all sure there is one. I've heard it said that everyone thinks he or she might write, someday, maybe,

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given the time. (It really isn't so, though.)

At any rate, here's **The Business of Being A Writer,** by Stephen Goldin and Kathleen Sky, two writers who happen to be married to each other. It is not a "how-to-write" book, though it grew from an SF writing course the authors taught at California State University, Northridge. They gave the students one three-hour session on the business aspects of writing—record keeping, copyright, royalties, legal matters, taxes, etc.—but felt the subject deserved a whole course. They talked the school into letting them do that course, and that became the book.

The book holds plenty any writer of experience knows already. She has learned the hard way how to work effectively, submit, market, deal with editors, and even keep records. Even this writer, however, may find illuminating what Goldin and Sky have to say about rights, copyright, contracts, fair use, obscenity, publicity, and especially taxes. On that last, let me say only that there are some expenses a writer can deduct on either Form C or the itemized deduction sheet. Deducting on Form C, however, shrinks the income on which she must pay the verdammt Self-Employment Tax. You can bet your sweet patooties I'm going to bear that in mind next time around! I hadn't thought of it that way before, more fool me.

The book's tone is pragmatic and antiparanoid. It lays out the publisher's point of view that the writer won't fly off the handle without justification. If it has the intended effect, it will keep many writers from antagonizing their editors and losing markets. It is thus a good investment for writers who feel publishers are out to rip them off. Some are, granted, but only in certain ways, and it's best to save the ire for when it's needed.

Let me call to your attention a handful of small, $2.95 paperbacks—indeed, a whole series of the things—from Borgo Press. First is The Milford Series: Popular Writers of Today. I have Volume 31, **Fantasy Writers 1,** offering reprinted interviews with Manly Wade Wellman, Gor's John Norman (really a defensive philosophy prof named John Lange), Hugh B. Cave, and Katherine Kurtz; Volume 32, **Masters of Science Fiction 1: Essays on Six Science Fiction Authors** (Hamilton, Brackett, Malzberg, Vonnegut, Silverberg, and Reynolds) by Brian M. Stableford; Volume 33, **Science Fiction Voices #4,** more interviews, these with Hornig, Shaw, Freas, and Stableford; and Volume 35, **SF Voices #5,** interviews with Asimov, Brackett, Lin Carter, Del Rey, Hamilton, Long, Simak, Tucker, and Williamson. I also have, reprinted from *Future Life* and *Questar,* answers from 22 SF writers to a pair of questions about **The Future of the Space Program, Large Corporations, and Society.** Finally, I have the wholly original book, No. 1 in the I.O. Evans Studies in the Philosophy and Criticism of Literature, **Science Fiction Westerns, Volume 1, Wilderness Visions,** by David Mogen ("the frontier subject is an important source of American science fiction's vitality." [p. 3]).

I think the labels describe the contents adequately. I won't try to describe the contents further. The books should sell themselves: *Visions* to academics, the interview volumes to author fans, now that I've mentioned them. I'll add that they're neatly made, and the price is not unreasonable.

For Scribners, E. F. Bleiler has edited

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Science Fiction Writers: Critical Studies of the Major Authors from the Early Nineteenth Century to the Present Day. It's a massive book, 640 8½"-x-11" pages and $55, covering 75 writers from Mary Shelley to Roger Zelazny arranged by group (Early, Primitive, Mainstream Georgian, American Formative, Circumbellum, Moderns, and Continental) and discussed by 26 contributors, including Bleiler, Stableford, Aldiss, Dozois, and the late Susan Wood. The individual pieces offer personal and literary biography plus an interpretation of the writer's general thrust. They seem generally cogent and even insightful. They should be an immense aid to English majors cribbing term papers.

The book's major drawback, predictably, is coverage. It includes three European SF writers (Verne, Capek, and Lem), but no Russian, Japanese, or Chinese. Neither does it include any of the current generation of writers, despite the subtitle; it omits Sheffield, Cherryh, Bishop, Crowley, Wolfe, Wilhelm, Bryant, and many more who may have a greater claim to literary brilliance and seminality than, say, Dickson, Hoyle, Matheson, or Oliver, who are covered.

But let's not knock the thing. What I'm picking on could well become Volume 2. As is, the book is bound to be useful, and it certainly belongs in every campus library. Goose yours. ■

IT'S ANLAB TIME AGAIN! This issue completes 1982 for *Analog;* now it's time for you to let us know how we're doing. The authors are interested, I'm interested, and you should be interested—because your feedback about your likes and dislikes will have a second-order feedback effect on what we offer you in the future. So please vote. Here's how:

Look over all your copies of *Analog* dated 1982. (There will be an index in the next issue.) From them, pick your *three* favorites in each of the following categories: novella/novelette (a *single* category), short story, science fact article, and cover. Then drop us a line listing your choices in each category, in order of preference. We'll tabulate the votes and let you know how they came out.

We normally ask for your votes on serials as well, but only two appeared complete during 1982: *Courtship Rite* by Donald Kingsbury and *Rails Across the Galaxy* by Andrew Offutt and Richard Lyon. We'd appreciate your comments on these, rather than votes; we feel the results would be more meaningful. (*Rocheworld,* which begins in this issue, will count as a 1983 serial.)

Please send your votes to: AnLab, *Analog,* Davis Publications, Inc., 380 Lexington Ave., New York, NY 10017, before February 1, 1983.

—The Editor

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brass tacks

Dear Dr. Schmidt:

In a letter (Brass Tacks, March 1, 1982), Mr. Jeff Mandel told of writing his congressman a reasoned defense of several space programs and of receiving a 15-minute long-distance call from the congressman asking his viewpoints on the program and discussing it with him. Mr. Mandel was amazed, and suggested that others who support these programs write their congressmen, since his experience indicates that they thereby "can have an effect on future appropriations for the space program."

I worked on the professional staff of the House of Representatives for 24 years (1952-1976) and, based on my own experience, would like to add my voice to Mr. Mandel's. I know for a fact that if most of the readers of this magazine alone were to write their congressmen, supporting space programs and giving a rational defense of them, Congress would force large increases in the program on Reagan, as a direct consequence of those letters. I will briefly explain why this is so and give a little advice on techniques to your readers.

Members of the House of Representatives must answer every letter that comes from a constituent. If they do not do this, they will not remain in the House, since they will soon be replaced by someone who *will* answer his mail. This means, then, that in most cases the letter from a constituent must receive a reasoned response. If your letter requests enlarged appropriations, he will either have to reply "Yes" or justify his "No" or "I haven't made up my mind yet." If your letter contains a reasoned defense of the program, he is going to have trouble justifying the "No" or "I'm undecided." Enough such experiences may change the "No" to "Yes."

Congressmen like to please constituents. It's how they stay in office. Vir-

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tually no one ever writes in opposition to space programs (or in support of them, either). Therefore, if a congressman receives 50 letters (say) supporting space, it looks to him as if there is an avalanche of support throughout his district for the program, and he will therefore fail to support it at his peril. This means that less than 22,000 letters to Congress, giving a reasoned defense of the space program and requesting increased appropriations, will provide 50 letters (on the average) to every member of the House, and will have an absolutely enormous impact.

Techniques. First, write your *own* congressman. Don't bother writing any other congressman—he almost surely won't read your letter; your own congressman very probably will. Second, write each of your senators. Neither of them is likely to read your letter, but the staffer assigned to space letters in his office will, and he or she will report to the senator the large interest in increased appropriations for space programs that has occurred in the state. Third, don't threaten reprisals if you don't get your way—that's the best way in the world to turn a representative or senator completely against you.

And, finally, express your support for increased appropriations, and give reasons. Point out the benefits we have already received from space programs, and the enormous benefits we will receive if we continue our efforts in space and increase them. Also point out that we will lose these benefits if we do not act and act now, since the competition for resources may reach a point in the future where these programs will be much less feasible than they are now. If you don't understand the preceding sentence, don't try to write a reasoned letter on your own; crib from Jerry Pournelle and his writings.

JAMES M. MENGER, JR.
Attorney at Law
Poway CA

Dear Stan,

The poignant letter from C.M. Fitchett in the May "Brass Tacks" prompts me to respond, because I too wish to see more accurate science in SF and because Ms. Fitchett is certainly not alone in her frustrations. Obviously there are many aspiring SF writers who shy from their typewriters when they begin to worry about the scientific details. No doubt the current rise in fantasy and science fantasy stories and novels is a reflection, in part, of the fears some writers have about making technical boo-boos in print. For the record, you may pass on my address to Ms. Fitchett as one who is willing to help.

As for Ms. Fitchett's plea for a consultation service, well, I've thought about that (and the perhaps more reasonable idea of a suitable reference book) and regretfully concluded that it just would not pay. Down the line, of course, home computers and new information nets will answer this question, but what is the harassed school teacher to do in the meantime?

Well, Ms. Fitchett, do what the rest of us do—continue to read, and meet people. Meet people by mail. At a given level of our society, no one is more than three personal contacts away from anybody else, and that truism certainly holds for the science fiction community. If you don't know how to fly a plane, you must know somebody who knows a pilot. Surely there is a person as close as your telephone who not only knows rheostats intimately, but can explain why that's probably not the term you want for a spaceship bridge. No one should be ashamed to ask questions.

And finally, Ms. Fitchett, if you con-

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tinue to worry about every scientific detail you'll never finish the story. If you really have a "hot story line" it will not matter if another writer plows similar ground. Hal Clement did not invent high-gravity planets, after all, and Shakespeare was hardly the first to realize that kings may have ungrateful daughters. Write about what you know best, and find out who to ask about the rest. Education rarely costs anything in this country; you only have to pay for the papers to prove that you are supposed to know something.

If this "secret" catches on, Stan, just think what it will do for your slush pile!

DR. DEAN R. LAMBE

Vincent OH

Dear Stanley:

Mr. Joe Patrouch ("The Ninety-Degree Error," in *Analog* for June 1982) might have had less flak from his English majors on the subject of imaginative fiction if he had reminded them that before 1719, with a few scattered exceptions, *all* fiction, from the *Odyssey* to *Gulliver's Travels,* had been what we should call science fiction or fantasy. Daniel Defoe's *Robinson Crusoe* of 1719 started the vogue for realistic fiction, which grew throughout the following centuries until it overshadowed imaginative fiction and came to be called "mainstream" fiction. But before Defoe, imaginative fiction *was* the mainstream, and it has continued to thrive alongside its younger rival.

Defoe, by the way, got his material in an underhanded way. The Scottish sailor Alexander Selkirk, rescued after being marooned on an island off the coast of Chile, came back to England thinking he had material for a book; but he had no writing experience. A friend introduced him to Defoe, who borrowed Selkirk's manuscript promising merely to touch it up and give it editorial polish. The next poor Selkirk knew, Defoe had published *Robinson Crusoe* under his own name and done very well by himself. Selkirk had to go back to sea to make a living.

L. SPRAGUE DE CAMP

Dear Dr. Schmidt:

With reference to "Specifications for Superman," (Feb. 1, 1982) I would like to suggest two things.

First, you state (in reference to genetic engineering) that, ". . . it's virtually certain that if the capability exists, somebody, somewhere, will sooner or later use it." Science fiction in general, and the editors of *Astounding/Analog,* have told us this for thirty years or more, and I have tended to believe it. Yet now I wonder. Within the past year, an article in the Sunday *New York Times Magazine* stated that scientists are convinced that *Homo sapiens* and *Gorilla gorilla* are interfertile. With our knowledge of artificial insemination, it would be easy to test this hypothesis, but I don't hear about anyone rushing to do it. Even though it might result in a *real* slave source, unapproachable (or un*re*proachable) by religion or Bill-of-Rights arguments. (We've had some SF along these lines in the past, but never before with actual scientific backing. Should be interesting, again.)

Second, I disagree with your (plausible) conclusion completely. You believe that improved information retrieval would be a superman-type assist to our race. However, the simplest computers have that capability now, and I don't see that it makes them any more adaptable than they would be without it, or than we humans are.

No, if I had my druthers, I'd like to have my "intuitive interconnects," whatever they might rightly be called,

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increased by about an order of magnitude. Of course, we don't know how these correlative functions work, as yet, and if we ever find out, I suppose we *will* build them into computers. That may *really* be our downfall. Until then, I believe that the human race will outdo any computer that's conceived, even as poorly as we now utilize these attributes. There's been a lot of SF along these lines too, much of it in *ASF/Analog*, although I don't recall reading any from the *robot's* point of view.

Thanks for giving us a "think-piece" in the tradition of JWC. Obviously, in my case, it worked!

DOUGLAS MCGARRETT

Jamaica NY

By now you've probably read Joseph H. Delaney's "Brainchild" (in our June issue), which came in a couple of months before your letter. The author is an attorney who expects to see a similar case in reality in the not-too-distant future. Personally, I'll stick to the claim that if a capability exists, somebody will eventually use it. History, to paraphrase an old cliché, is young!

Dear Dr. Schmidt:

I have finished the serial by Donald Kingsbury. *Courtship Rite* was excellent! In the January 4 "In Times to Come" you said the societies would not be trivial modifications of our own. There have been very few truly alien societies described in science fiction. This was one. Harry Harrison, writing in the style he used for *Deathworld* or *Planet of the Damned,* could have described this society sympathetically —from the *outside*. Kingsbury made us live it from the inside; not sympathetically or unsympathetically, "merely" as reality. Whether or not this work wins an official award, it gets one from me. What a conflict when Geta discovers the rest of the human race or vice versa! If I were to write that story, I would have serious trouble deciding which aspects of humanity I would write as currently dominant in the rest of the race and how much different should I assume the means and standard deviations of the two populations' "intelligence" to be.

DEAN S. HARTLEY III

With luck. Kingsbury will write that story and Analog *will be able to bring it to you.*

Sir:

The Arkansas court fight and its attendant publicity against teaching the creationist version of the origin of the world shows that too many scientists are as inflexible and dogmatic as orthodox theologians. They all forget that truth can only be observed or deduced from observed facts: neither legislative nor judicial fiat can establish a truth or change a natural law.

We underestimate the intelligence of our children; they are quite capable of discovering the truth by themselves. They only have to compare what they are taught to what they see to find out. They catch on to the truth quickly; they just don't let the adults know that they have caught on to their little games.

Creationist doctrine is no worse a fallacy than most of the other dogmas that legislators and judges are shoving down the throats of school children. Why single out the creationists? Actually, teaching creationist and evolutionist doctrines side by side would be a good way to sharpen children's judgment, and a convincing way to demonstrate that all that is authoritatively decreed is not the truth.

ANDREJS BAIDINS

Wilmington DE

It's true that some scientists are more

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inflexible and dogmatic than they'd like to admit, but the fact remains that there is not time to teach every conceivable idea and, like it or not, some selection is necessary. By the scientific standards I know and can accept, creationism in the forms I've seen has precious little to support it; by all means mention it, but I see little way to justify giving it equal time because the evidence *points strongly in another direction. And while I agree that adults after underestimate the intelligence of children, I also know that most children's critical faculties still need a lot of sharpening (which most of them, unfortunately, will never get) and many of them are all too willing to accept as gospel whatever a teacher tells them—which should be a pretty sobering thought for a teacher of any persuasion.* ■

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26-28 November
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26-28 November
MYSTERYKON 7 (Texas SF and fantasy conference) at Houston, Texas. Info: Mysterykon 7, Box 713, Stafford TX 77477.

27-28 November
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13-17 December
Eleventh Texas Symposium on Relativistic Astrophysics at Austin, Tex. Info: American Physical Society, 335 East 45th Street, New York NY 10017.

13-17 January
STARCALL (Pro-space SF-related conference) at Washington, D.C. Art show, hucksters, writer's and artist's workshops, NASA science and engineering panels. Guests—Gordon Dickson, Frank Kelly Freas, James Gunn, C.J. Cherryh, etc. Info: STARCALL, 225 Church St. NE, Vienna VA 22180. (Enclose self-addressed stamped envelope.)

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—Anthony Lewis

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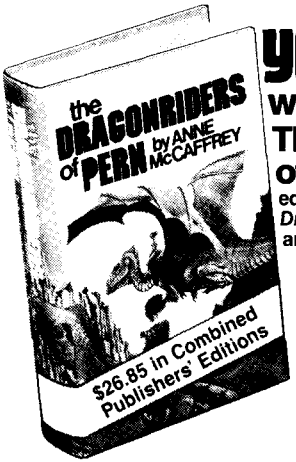

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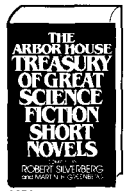

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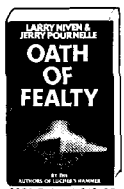

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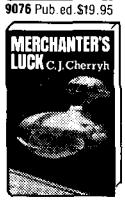

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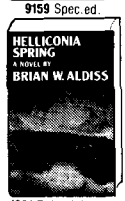

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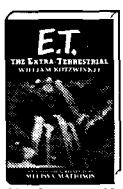

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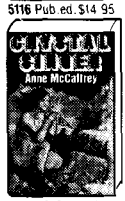

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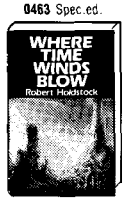

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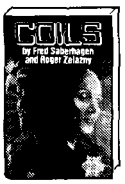

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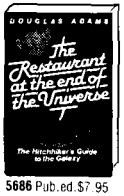

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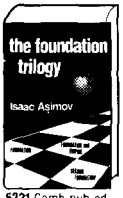

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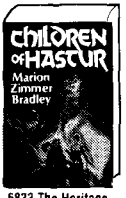

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